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MINISTRY OF AGRICULTURE AND FISHERIES.

Agricultural Meteorological Scheme.

Bibliography of Literature on Agricultural Meteorology.

Section 2. Extracts & Summaries.

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SECTION II.

EXTRACTS AND SUMMARIES.

An asterisk is used to denote an author's summary or conclusions.

1. *During several years of study on the grain weevils, the writers have observed that the rice weevil and the granary weevil differ markedly in their resistance to high and low temperatures. In order to obtain more precise information a number of laboratory experiments were carried on with small refrigerator units and incubators. At a constant temperature of 0°F. adults of the rice weevil were killed after an exposure of 4 hr. and adults of the granary weevil after 5 hr. Up to a certain point, as the temperature was increased, the difference in resistance between the two species became more and more apparent. At a temperature of 5°F. an exposure of 4½hr. was sufficient to kill adults of the rice weevil, whereas 7½ hr. were required to kill adults of the granary weevil.

Temperature. From	to	Rice weevil lived.	No. of days.	Granary weevil lived.	No. of days.
15°F.	20°F.	"	3	"	14
20°F.	25°F.	"	3-6	"	33
25°F.	30°F.	"	8	"	46
30°F.	35°F.	"	8-16	"	73
35°F.	40°F.	"	18	"	111

From 40°F. to 45°F. adults of the rice weevil were killed in 80 days, this slight increase in temperature associating itself with a marked increase in longevity; specimens of the granary weevil were still alive after 105 days. From 50°F. to 60°F. the normal lives of both species were greatly prolonged. Adults of the rice weevil lived for 558 days and specimens of the granary weevil for 873 days The normal lives of the two species in summer is from 100 to 200 days and from 200 to 250 days respectively. In the immature stages, these two weevils show similar differences in their powers of resistance to low temperatures. The susceptibility to low temperatures varies so much in individuals of the same species that very large numbers must be experimented with in order to arrive at definite conclusions regarding the lethal qualities of any one temperature. The foregoing figures cannot be considered quite final until further experiments involving many more individuals have been completed.

The effect of high temperatures on the two weevils is also of interest. From 95°F. to 98°F. adults of the rice weevil were killed in 9 days; adults of the granary weevil in 13 days. A temperature of 120°F. killed adults of both species in 3 hr., and a temperature of 130°F. within 30 min. It is interesting to note that oviposition ceased at a constant temperature of 94°F.

2. *Experiments to determine the best time to sow seed of western white pine have been carried out in the northern Rocky Mountain region since 1912, mainly at the Savenac nursery in western Montana. Climate and soil combine to

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make the problem essentially local, but although the findings may not apply directly elsewhere the observations may be found suggestive. In order to understand the problem it is necessary to know something about what is termed the "holdover characteristic" of western white pine seed. Like the other five-needled pines, this species has a strong tendency not to germinate all of its viable seed the first season after spring sowing. At the Savenac nursery this delayed or second-season germination is often as high as 50 per cent., and has been anywhere from 4 per cent. to 91 per cent. of the total number germinating from spring sowings. In order to eliminate this hold-over characteristic, attempts have been made to hasten the germination of the seed by various treatments before sowing. Experience has shown, however, that most of the methods used tend to lower germinative capacity and at the same time do not uniformly accelerate germination.

Because the results of these trials of spring sowing were all unsatisfactory, the possibility of autumn sowing was considered. The early experiments resulted in prompt and complete germination the following spring. The superiority of autumn over spring sowing of this species was so marked that it seemed as if the problem were solved, but it soon appeared that the correct time in the autumn for sowing was also very important. It was found that the best time for sowing at the Savenac nursery is during the first two weeks in September. The last few days in August may be as good, but this is not certain. August sowings are subject to premature germination, and seedlings germinating prematurely do not survive the winter.

3. *Experiments on the incorporation of straw in soil showed that the temperature of soil thus treated is lower in its surface layer in the morning and higher in the evening than that of untreated soil. The radiation of heat from the surface layer of treated soil during the night seemed to increase as the proportion of straw incorporated was increased. This is taken to indicate a possible injury by frost which sensitive crops may suffer in soil in which straw has been incorporated.

Experiments on the incorporation of horse manure in soil showed, on the contrary, that such soil was warmer in the morning than untreated soil. The surface layer of soil treated with horse manure cooled more rapidly and the subsurface layers more slowly during the night than the corresponding layers of untreated soil. Soil rich in humus was found to be warmer in its surface layers during the day and cooler in its subsurface layers than soil not so well supplied with humus. During the night the order of temperatures was reversed.

These results are taken to indicate that the more rapid cooling of soils rich in humus during the night is favourable to the injury of crops by frost. A moderate use of organic fertilisers is suggested when there is danger of frost.

4. *This paper is the report of the methods and results of a large scale statistical reduction of the Rothamsted records of rainfall and wheat yields. The objects of the enquiry were (i) to ascertain the actual effects of varying rainfall as a factor in crop variation; (ii) to discover

the

differential responses to rainfall of crops grown under different manurial treatments: (iii) to lay a foundation both of statistical method and of ascertained fact for the agricultural evaluation of a particular season's weather, as is required for any effective system of agricultural insurance.

The greater part of the paper is devoted to the solution of mathematical problems, and the development of statistical methods adequate to handle the type of data which it is required to treat. The procedure which emerges from the solution of these problems consists in making a detailed analysis of the weather sequence in each individual year for which crop records are available, so as to obtain the measures of the several meteorological characteristics of each year. The yields are then expressed in terms of these measures in such a way that the average effect of a given weather variation upon the final crop can be calculated for all times of the year.

This procedure is applied to 65 rainfall sequences, and the average effect at all times of the year of an inch of rainfall is obtained for the 13 plots of Broadbalk wheat field which have been for the whole period under uniform treatment. Plots differently manured show very striking differences in the rainfall response, showing that the prevailing climate is a considerable factor in determining the suitability of manurial dressings. All plots show that the rainfall of the district is on the average in excess of the requirements of wheat, but several plots indicate that more rain would be advantageous in October. All plots receiving nitrogenous fertilisers including the 17 and 18 mineral series which receives only residual nitrogen, show a considerable loss of yield due to rain in January, which is apparently due to the loss of nitrates in drainage water. Those plots in which nitrogen deficiency is of rarest occurrence, such as the dunged plot and plots 10 and 11, show an even heavier loss due to rainfall in July and August.

Rainfall variations make an important contribution to the yield variation observed. In this respect rain is perhaps more important than any other single meteorological factor. It will not be possible to treat the other meteorological factors with the same precision, since the records of temperature and sunshine do not go back to the beginning of the experiments.

5. The fact that a plant may transpire more water than a 'water body' of equal surface evaporates led to experiments to measure the transpiration of representative prairie communities. This was done by encasing sods in the true prairie, mixed prairie and short grass plains in 3 ft. cylinders without disturbing the roots and weighing these at the desired intervals.

It was found that the transpiration in each community was more than the precipitation. The cereal crops were found to transpire at about the same rate as the native grasses, while alfalfa lost somewhat more water. The results explain why ordinary settlement and cultivation have not increased rainfall, but suggest that afforestation over wide stretches would do so.

6. In the study of the effect of environment on the growth of plants, it is difficult to show the exact relationship between soil moisture and crop yield. Rainfall data alone are not sufficient as a measure of the amount of water available for plant growth, because drainage and evaporation remove a variable quantity of water. Nor is a knowledge of the total moisture content of a soil sufficient, as different types of soil hold water with different degrees of tenacity, and a plant can never entirely deplete a soil of its moisture. The rate at which plant roots may draw upon the moisture depends upon the ease of transference of water in the soil, and this depends upon the permeability of the soil as decided mainly by texture.

In 1920, Dr. Livingstone measured directly the water-supplying power of a soil by the employment of porous porcelain cones (soil points). The gain in weight of these points when pushed into the soil, and allowed to remain there for a definite time, was taken as a measure of its water-supplying power. The method was developed by Dr. Mason who used ordinary writing pencils as soil points.

The author applied Mason's method to field problems, details of his procedure having already been published in J. Agric. Sci., XII, No. 4, 1923. The investigations were carried out on a sugar estate in Antigua. It was noted that the canes in certain fields suffered less from drought than those in others, and the difference had been assigned to differences in calcium carbonate content of the soils. The soil-point method showed that the water-supplying power of the more calcareous part of the estate was greater than that of other parts. No direct relationship was found between the total soil moisture and the water-supplying power.

The conclusion was drawn that crop yields show fair positive correlation with water-supplying power of soil.

The differences that various crops exhibit as regards their water requirements at different stages of growth, and the response of the soil to these demands, may be demonstrated by the use of soil points.

7. The authors take as the source of their information the carefully registered results of the second and third National Egg-Laying Competitions of Vaulx-de-Cernay. The meteorological data were collected at the same time by the meteorological station of the Competition and by another meteorological station of the domain of Vaulx-de-Cernay.

The hens were fed with the view to encourage intensive egg-laying. The individual effect of the greater or lesser susceptibility of one breed to either cold or heat, was eliminated by the fact that a very large number of breeds were entered for the Competition and the authors considered the results obtained from all the lots together. In the same manner, on account of the large number of birds, the periods during which egg-production ceased may be supposed never to have coincided in the case of all the hens, so that the daily output of eggs did not fall as a result of these periods.

The analytic study of the egg-laying shows an important factor, viz. the influence of the season. It is seen that few eggs are laid in winter, and that the winter-layers belong to the same lots, so that winter egg-production is a question of age and of physiological maturity.

<u>Results</u>

Results obtained in the seasonal study.

In winter, few eggs are laid and the output of eggs depends upon a limited number of birds whose high egg-laying capacity renders them insensible to variations of temperature. Egg production is distinctly decreased by the first cold, though a series of days with low temperature has little effect. Hens readily adapt themselves to any given temperature, but they cannot stand changes in the temperature. Wind has little effect unless the temperature changes suddenly, but if accompanied by a cold rain, the effect is most injurious. Windless rain only influences egg-laying in so far as it reacts upon the temperature.

In spring egg-production increases in spite of great daily variations in temperature. Very high, or very low barometric pressure often decreases egg-laying, the effect showing itself on the day, or the evening of the maximum or minimum pressure. Egg-laying is not arrested by a low temperature that falls progressively. The first warm days are favourable, but the first hot windless days reduce the number of eggs. A warm wind unaccompanied by rain is favourable to egg-laying and a warm wind coupled with rain regularly increases the output of eggs.

In summer, egg-production is high at the beginning, but flags during the intense heat and rises again in the autumn. All extremes of barometric pressure have a bad effect upon laying-hens. Great heat and sudden cooling off of the atmosphere both cause a fall in egg-laying. Winds in summer, even if they are stormy, have little effect. Rain, whether violent or not, is injurious on the day of its fall, but improves egg-laying during the following 2 or 3 days. Continuous rain for 2 or 3 days decreases the number of eggs, which however rises when the weather is fine again.

As regards the autumn, the time when the egg-laying competition finished, no exact data exist.

Study of effects of natural phenomena.

I. Barometric pressure. Effect undeniable, but not clear. The birds dislike extremes of pressure and prefer average pressure.

II. Temperature. Average temperatures are the most favourable. The best climate is that of which the seasonal variations are progressive, but not abrupt. Severe cold appears less injurious than great heat.

III. Wind and rain. These must be studied together and in connection with the temperature. The effect of wind seems to be due to its altering the temperature, for the isolated action of wind is not defined. Wind accompanied by warm rain appears beneficial; cold wind and cold rain are injurious. Summer rain is favourable except on the day it falls.

It may be concluded that there is no simple co-ordination between the phenomena studied. A distinction must be drawn between simultaneousness and correlation. When hens are physiologically in a condition to lay eggs, they are not deterred by cold, while if they are not ready for laying their failing in egg-production is not to be attributed to low temperatures.

8. *In order to consider the ecological distribution of the crane-flies of Carnarvonshire, 16 different habitats were carefully chosen to give as fair a representation of the distribution of the adult flies as was practicable under the conditions of the work. The most thickly populated habitat is the immediate neighbourhood of lakes, streams and rivers. All the habitats which have a large crane-fly fauna are characterised by a plentiful water supply and a large amount of shade. The relative humidity in such places is often high as there is a great deal of evaporation from the streams, lakes ditches, etc. The texture of well-kept garden soil facilitates evaporation, so gardens rank among the most thickly-populated habitats. On the other hand, not a single crane-fly has been recorded from the sand dunes. The more exposed the habitat is, the less dense is the crane-fly population regardless of the amount of water available. The small number of adult flies found in fir and pine woods is probably due to the lack of undergrowth and the resultant decrease in retention of moisture.

Though no direct comparisons of abundance of these insects with measured atmospheric moisture have been made a comparison with the occurrence of rainfall in the summer of 1923 indicates that the optimum weekly rainfall for crane-flies under the conditions of Carnarvonshire appears to lie between 0.55 in. and 0.95 in.

There is also a correlation between temperature and the number of crane-flies on the wing, but the data are inadequate to any detailed discussion.

Excepting its effect on relative humidity the chief influence of wind on crane-flies is to drive them into shelter. The conclusion that there is any direct correlation between wind and number of adults occurring must therefore be guarded against. No adequate data are available.

So far as the rather scanty data available allow of a conclusion, it appears that the bulk of the species are lowland forms, and that above 1500 ft. the crane-fly fauna is negligible. Some species occur only below 500 ft. and a few only below 200 ft. The majority, however, depend almost entirely on the range of their own ecological habitats. For instance, the flies characteristic of mixed woods occur in these whether they are at sea-level or at an altitude of 600 ft.

9. *Temperature has less direct influence on vocal-energy than any other factor. Its effects can be interpreted only in a general sense, and from a seasonal point of view. As the thermometer slowly rises with the advancing year, so will the singing impulse show a corresponding rise, whilst the other conditions remain seasonable; but let the weather play tricks, and down will go song-power, though the temperature may be 80°F. In other words, the influence of temperature is only secondary to such factors as the force and direction of the wind, and the state of the atmosphere.

A high temperature is more favourable with cloudy conditions than with clear, with winds than with calm.

Cloud and rain, with calm conditions, have but little influence one way or another. During a quiet, steady drizzle most species will sing much as usual: but add to this a moderate or strong wind, and they are mostly silent.

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A rising or falling barometer has little or no effect on vocal energy. Other conditions being normal, birds will sing as usual either immediately before or after a storm.

The most favourable influence of all is a clear sky with a still atmosphere, irrespective of temperature.

The most unfavourable influence is a gale but only when accompanied by a low temperature. The influence of temperature is more marked in winds of gale force than in any other condition.

In conclusion, it is hardly necessary to add that the observations recorded are purely experimental, and that if the problem should ever be finally solved it will not be by the methods employed in this investigation. But that is not to say the data are of no scientific value. Covering, as they do, a period of three years, under all sorts and conditions of weather, they may well be of use to those who investigate the subject more fully, and more scientifically.

10. Sugar production in Java has now for some time shown a constant increase, but also considerable oscillations from one year to another. The authors investigate the causes of such increase.

Apart from other factors, such as progress in irrigation in cultural methods, etc., the authors find that the crop is greatly influenced by climatic conditions. Among these, particular attention is given to the monsoons and rains, which latter are very abundant (from a minimum of 1,314 mm. per annum to a maximum of 3,388 mm.). By applying the formulae of the statistical method, the authors find that it is possible to establish a correlation factor between sugar production, the October and November rains and the time of planting. This factor is 0.88 and enables the year's crop to be calculated very approximately when the October and November rainfall and the time of planting are known, it being remembered that between the latter and the harvest there is an interval of nine months. With the same data the yield also may be calculated, in this case the correlation factor is 0.95.

11. *The dense centres of sheep population in the world are found within comparatively narrow limits of temperature, rainfall and humidity. The mean temperature ranges between 28°F. and 77°F., the rainfall between 0.3 in. and 4.5 in. per month; the relative humidity between 55 per cent. and 70 per cent. at the higher temperatures and 65 per cent. and 91 per cent. at the lower temperatures. Such conditions afford mild winters, cool summers, and sufficient rainfall to provide good grazing.

Climatic conditions must be favourable, especially during the critical periods of rutting season, pregnancy, lambing, and the growth of the lambs. The lambing period generally comes in the spring, enabling the lamb to get a good start before hot weather sets in. In the spring there is also an abundance of forage for the suckling ewe. The

growth

growth of the lamb is retarded by high temperature and humidity, by excessive rainfall and cold weather. The rutting season comes with a falling temperature and possibly a rather wide range between the maximum and minimum temperatures. Unfavourable conditions at the rutting season or during the gestation period tend to produce a small fall of lambs, and often weak lambs. If these critical periods are greatly disturbed, sheep are not likely to be numerous or profitable.

In Illinois, conditions of good sheep years are found to resemble the average conditions prevalent in the best sheep countries. The bad years generally have unfavourable conditions at some of the critical periods. The most serious condition here is the hot summer with a high humidity. No practical methods of overcoming these conditions are known. At Urbana, Ill., a mean temperature of over 70°F. accompanied by a mean relative humidity over 80 per cent., retards the growth of lambs. A higher temperature can be tolerated if the humidity is lower.

More attention should be given to finding breeds best suited to a locality, since the Rambouillets seem to stand the unfavourable conditions during the summer at Urbana, Ill., better than the Southdowns or Shropshires.

In some sections the limits of successful sheep production can be extended by proper methods of housing. The barn maintains a much more uniform and higher temperature and humidity than the shed or out of doors. But conditions in the barn are not entirely satisfactory for the health of sheep.

Sheep thrive best where cool summers and mild winters prevail and where sufficient rainfall is afforded to provide good grazing.

12. The results are given of co-operative experiments carried on between the Alabama Experiment Station and the U.S. Department of Agriculture on the conditions favouring the development of citrus scab. Three essentials are considered for successful infection of citrus plants under controlled conditions. These are the presence of free moisture, young growth, and temperatures between 15°C. and 23.5°C. The optimum for the best development of scab is said to be about 20°C. to 21°C. Under Alabama conditions, temperatures favourable to optimum infection are said to prevail usually during parts of April and May. Any environmental factor or factors including a slight spring growth and rapid maturation or late starting favour escape from scab, while factors inducing a large amount of spring growth and slow maturation favour scab susceptibility.

The authors state that conditions essential for an epidemic scab year in Alabama depend to a large extent on a late season, coupled with sufficient moisture and the development of spring growth at the time optimum temperatures for infection prevail. An early season is said to be favourable to scab escape, in that the first growth is about completed when optimum conditions for infection are at hand.

It

It is claimed that under Alabama conditions a light or bad scab year can be predicted to some extent by the mean temperature prevailing in March, a temperature below normal indicating a bad season, while a temperature above normal is usually followed by a light scab year.

13. This study is of unusual interest because of the fact that cotton in Egypt, grown principally in the extreme lower Nile Valley, is a summer crop, while in the Sudan, extending from the Central and southern districts of the Red Sea westward to the upper Nile Valley, it is grown as a winter crop. In Egypt the seeds are planted on a rising temperature, usually when the mean daily values rise to about 60°F., while in the Sudan they are planted on a falling temperature, ranging from 90°F. to 80°F. The lowest temperature on record at any of the Egyptian stations in the cotton area is 25°F. while in the Sudan the lowest on record is 37°F., and by reason of the difference in the time of the cotton season, the growing plants escape the extreme cold in Egypt and the extreme heat of the Sudan.

In both sections cotton is mainly, but not entirely, dependent upon irrigation. There are a few places in the southern Sudan where it is grown under natural rainfall, and in a few other low-lying parts irrigation is not practised, but in these cases percolation takes place from the surrounding country. In some cases the crop is dependent on the flood waters of the rivers, and in others on the artificial application of moisture. Because of the fact that evaporation is high in regions where irrigation must be practised, this factor is given considerable attention; in Egypt, cotton is produced at the time of greatest evaporation, and in the Sudan at the time of the least.

The author makes the following comments on the number of hours of daylight under which cotton is grown in the two sections:-

> 'Recent investigations have shown that the number of hours of daylight to which a plant is exposed may have great influence on its periods of growth and maturity. Without wishing to make any statement as to whether or not cotton is so influenced, it may be of interest to put on record the actual number of hours of daylight in the different localities in the different stages of the crop.
>
> 'They show that while the Sudan has the most hours of daylight in the close season, during the growing period the cotton there has from 2 to 3 hr. a day less than in Egypt. As the Sudan is probably the furthest locality from the Equator at which cotton is grown as a "winter" crop, it is probable that these figures represent the shortest hours of daylight under which the cotton is cultivated.
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> 'The greatest similarity of conditions between Egypt and the Sudan is found at the time of planting and again at about the middle of picking.'

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14. * The purpose of the investigation was to study the relationship between the yield of corn and rainfall and to consider the influence of fertilizers on the relationship. Both the corn yield and rainfall records cover a period of 15 years, viz. 1909 to 1923. The corn crops studied were planted during the latter part of April or the first part of May. The relationship was determined for the corn year, April to September, inclusive; for early summer, May and June; for late summer, July and August, and for the individual months. The equations indicate that an increase in rainfall for the corn year is accompanied by an increase in corn yield. An increase in rainfall during May and June gave a decrease in corn yields under two treatments and a reverse result under the other two treatments. During July and August an increase in rainfall resulted in a decrease in one case and an increase in three cases.

The relationship existing between rainfall and corn yield for the individual months of the corn year is approximately what is to be expected. An abundant rainfall in April allows moisture to accumulate which can be later used by the developing corn plants. A relatively dry May offers opportunity for the ground to become warm and as a result the corn germinates more rapidly and vigorously than in cold damp ground. As the corn plants develop they use more water and as a consequence the ground becomes comparatively dry. Hence an increase in rainfall in June is more beneficial than a decrease. It seems that when sufficient water is supplied in June for the needs of the plant a too great additional supply in July actually reduces the yield of corn. A wet August seems to be highly favourable to corn production. In September an increase in rainfall decreased the yield in two cases and increased it in two cases.

It is found that for high yields rainfall should be comparatively low in the early part of the corn growing season and comparatively high during the latter part. For the highest yield of corn, wet and dry months should alternate.

15. Roots of the Vineless Yellow Jersey variety of sweet potatoes were severely infected by pox (Cystospora batata) when grown in infected soil at 4 per cent. and 6 per cent. moisture. At 8 per cent. and 10 per cent. the edible roots were not attacked, but the feet roots showed a large number of pox spots. At 12 per cent., 14 per cent., and 16 per cent., infection was very slight and the maximum yield was obtained. At 18 per cent. (soil saturation) there was no infection. These results explain the frequent failure of the crop in dry seasons and its success under suitable moisture conditions.

In

16. In its early stages the study of plant diseases resolved itself into little more than a study of the parasites. Later the study of the host plant received greater prominence and still more recently has come the recognition that diseases caused by parasites are the manifestations of complex interactions of host and parasite under the influence of a varying environment. Not only is the influence of that group of environmental factors termed the weather very marked but also it is evident that the same weather has a different influence on different diseases. Weather and climate depend on the same set of factors - temperature, humidity, light, wind, etc. - and if it is desired to understand the relationship between meteorology and disease, an attempt must be made to evaluate the influence of each of these factors on the interaction between host and parasite. As yet data are somewhat scanty; temperature, humidity and radiation are the chief factors about which data exist.

Moreland found that whether an epidemic outbreak of rust on wheat in India occurs or not appears to be decided by the humidity of the air in January and February (the crop being sown in October and harvested about April) and experiment has shown that it is the humidity of the air within the crop that is of consequence in deciding the relative severity of attack as between light and dense growth in the same field.

A good deal is known of the conditions of temperature and humidity that influence potato blight. In all cases it is worst where the humidity is high. In localities like the Channel Islands and the West of Ireland the humidity conditions are usually suitable and temperature is likely to be the controlling factor in most years.

Another group of diseases that appears to be closely influenced by weather conditions is the powdery mildews which are sometimes said to be worse in England in dry years.

One of the most complete studies of the influence of temperature on a soil-dwelling parasite (the sore-shin disease of cotton) shows the seasonal prevalence of this disease in Egypt to be practically a purely temperature reaction affecting chiefly the parasite.

There is a group of four of the major diseases of cultivated plants in India (potato blight, sorghum smut, wheat bunt and maize smut) strictly limited in their normal distribution by the temperature relations of host and parasite, the influence on the parasite being the chief.

The practical interest and importance of this study scarcely needs emphasis. In France there has been for some time in operation a system of meteorological notifications from a central station of the dates on which vine diseases are likely to appear. It is possible to predict sporulation seven days in advance, which gives ample time for protective measures. In Italy a similar service is in operation. In Germany the collection of data by means of a system of report cards has been commenced and an attempt will be made to correlate the incidence of certain diseases with meteorological data. A search is also being made for indicator plants which may be found to have a reaction to seasonal conditions parallel

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with that of the parasites. Hiltner has already claimed that he can find a strict relation between the date at which snowdrops bloom and the extent of the plague of field mice which occurs from time to time in Bavaria. The United States Weather Bureau is carrying on a large investigation to determine the effect of current meteorological factors on the growth of vegetation.

The object of this paper, however, is rather to stress the importance of beginning at the other end - of first establishing the temperature and humidity relations of the parasite and host, singly and together, and only then, with the exact information thus gained, seeking the correlation with meteorological data. Whether the meteorological data at present recorded are sufficient is doubtful. For the purpose here indicated, not only the means but the duration of the daily extremes of temperature may be of the utmost importance, a low minimum, if sufficiently prolonged, being perhaps sufficient to start a parasitic attack. The trend of recent work has been to show that definite conclusions cannot safely be drawn from field observations unless they are controlled and elucidated by the more exact methods of laboratory research.

17. *Rain and snow possess a distinct fertilising value from the soluble nitrogen compounds they wash out of the atmosphere and the present inquiry lasting over 17 years has had for its object the determination of this value in the precipitation - summer and winter - at Ottawa.

It is found that there is a much larger amount of nitrogen washed out by rain than by snow. There are two factors to account for this: the larger precipitation as rain and the fact that rain more thoroughly cleanses the atmosphere than does snow.

From a study of the data it would seem fair to conclude that the amount of nitrogen furnished, per acre, by the rain and snow in the neighbourhood of Ottawa would be approximately 6.5 lb. annually.

18. * A humid atmosphere accompanied by a medium to high temperature appears to be most favourable for the development of many bacterial and fungous diseases. Consequently, attention has mainly been given to temperature, precipitation and higher humidities, while the role of evaporation, especially of high rates of evaporation, has been decidedly less studied.

In the case of western yellow tomato blight a certain seasonal march of evaporation means a definite progress of blight in the same season. The summer of 1924 was marked by a particularly severe outbreak of this disease in a number of widely separated regions of Western America, which correlates with an unusually high evaporation in the districts in which it occurred. The rate of evaporation was in every case above the average of a number of preceding years. This condition was due mainly to a lower relative humidity and a greater wind movement. The departures from normal of mean temperatures were not significant and not uniform for the various blight districts.

The

The comparison of the percentages of blight at the experimental plots at Riverside and at Shafter (California) indicates that the rate of evaporation is not only concomitant with the severity of blight in different seasons in the same locality, but also correlates with its geographical distribution.

Out of nine localities for which evaporation records are taken, five are in blight areas and have the average monthly evaporation during the blight period over 7 in. and the other four are in non-blight areas with the average monthly evaporation for the same period at or below 7 in. Blight areas during the principal blight period seem to have the average monthly humidity below 35 per cent., while non-blight areas about or above 50 per cent. High evaporation is not only attendant on, but also foreruns severe spells of blight, especially at the outset of the season.

When the evaporation drops to a low level for a more or less protracted period, such blighted plants as are not in the last stage of the disease, show a partial, but seldom complete, recovery.

19. * The data regarding the influence of temperature upon infection and decay of six species of rhizopus are presented in this paper.

The time required for rhizopus to infect sweet potatoes wounded but not artificially inoculated varies from 5 to 7 days at 9°C, to 43 hr, and less at 18°C to 32°C. This time would be expected to vary with the amount of wounding and the number of spores present on the potatoes.

The six species of rhizopus studied can be placed into two groups according to their temperature responses, as follows:- A high-temperature group, R. tritici, R. oryzae, R. maydis, and a low-temperature group, R. nigricans, R. reflexus, and R. artocarpi. The optima for the high temperature group vary from 32°C. to 35°C., the maxima are about 42°C. and the minima vary from 3.4°C. to 9°C.; the minimum for R. maydis has not been definitely determined. The optima for the low-temperature groups vary from 18.5°C. to 24°C. the maxima from 30°C. to 34.5°C., and the minima from 3.4°C. to 12°C. The extreme temperature limits over which the entire group will infect sweet potatoes are between 3.4°C. and 42°C. R. tritici will infect over this entire range. The two strains of R. nigricans have a slight difference in their temperature response, the one having a slightly higher maximum than the other. The increase in the amount of decay with the rise in temperature is large, being four to ten times as much at one temperature as at 10°C. below.

20. *Helminthosporium sacchari was grown in standard nutrient agar and standard bouillon at eight different temperatures. Under the conditions of the experiment the optimum temperature for this fungus was found to lie between 20°C. and 29°C. The optimum, however, in nutrient agar remained constantly at 29°C. for the first 7 days, when growth ceased at that temperature. Within the optimum range (20°C. to 29°C.) the reaction of the bouillon became distinctly alkaline, whereas only a slight change in p H occurred at those temperatures at which the growth was slight.

21. Of the factors which cause frequent very serious decreases in the yields of Wheat in Western Canada, the lack of sufficient or timely rainfall is the most potent. There are some years which are so dry that the wheat is not worth harvesting. Under such conditions it becomes imperative that something be found which will combat drought more successfully. Experiments are being conducted under controlled conditions in order that definite comparisons may be made between various crops, rotations and cultural treatments. The experiments are being conducted in tanks 5 ft. in depth and 15 in. in diameter. The soil is dug from the ground in layers, each layer shovelled separately and placed in the tanks so that all tanks will have absolutely uniform soil and subsoil conditions conditions. As only 25 plants of cereals and grasses or 1 plant of corn, sunflower and potatoes, can be used per tank, it is not yet known what number of plants or how many tanks will be required to overcome the variations in individual plants. In order to make conditions in the tanks resemble field conditions in so far as wind and light are concerned, a small area around each tank is sown with the same crop as is used in the tank. The tanks are weighed regularly to learn the amount of moisture which the various crops have used.

The transpiration required to produce corn and potatoes is much less than that required to produce wheat. Hay crops not only require more water to produce each pound of dry matter but require the rain earlier in the year. Corn and potatoes utilise both early and late precipitation. It is not known absolutely the exact stage in the development of the crop at which the rainfall is most beneficial, but it appears to be about the time of heading.

It is hoped that the controlled experiments with different rotations may indicate which rotation is most economical in its use of the soil moisture. The amount of moisture conserved by summer fallowing and by different methods of handling stubble is being studied. It has been shown that the soil mulch is not effective in conserving moisture. Weeds remain the arch enemy not only of soil nutriment but also of soil moisture.

22. * Rainfall from a gauge protected from birds and from one not protected was analysed for a period of 15 months for sulphur, nitrate and ammonia. The total amount of sulphur in lb. per acre for 15 months was 56.07 in the rainfall from the protected gauge and 50.61 in that from the exposed gauge. The nitrate in the rainfall for the same period was 0.81 lb. per acre in the exposed gauge and 0.71 lb. in the protected gauge. There was a total of 17.44 lb. per acre of ammonia in the water from the exposed gauge and 9.81 lb. in that from the protected gauge. The greater amount of ammonia in the former may have been due to biological activity on the bird droppings.

The larger amount of sulphur in the rainfall from the protected gauge may have been due to actual loss of sulphur by biological activity in the water containing bird droppings.

23. * The main cause of vapour movement has been ascribed to the inequality of aqueous saturation between soil air and external atmosphere. In order for water to leave the soil in a vapour stream, heat must penetrate the soil to convert water

into

into vapour and the vapour must make its escape. The fundamental law controlling evaporation is the law of the saturation deficit. According to this law, the rate of evaporation into space varies as the degree of unsaturation - measured in grams per unit of volume - which is determined by the temperature of the liquid evaporating and the temperature and humidity of the atmosphere into which vapour is passing.

The first principle of evaporation control is to keep the saturation deficit as low as possible. This is done in practice by shade, which keeps the soil cool, by windbreaks, and by mulches, either of soil or other material which keep a highly saturated air blanket next to the soil. The second principle of evaporation control is to keep the soil in a condition that will prevent free passage of vapour into external atmosphere. Large pore spaces and cracks offer very ready escape of vapour. Probably a large part of the moisture in soils which is lost into the air in ways other than through plants is lost in a vapour rather than in a capillary stream.

Laboratory and field data show the magnitude and importance of vapour movements. The evaporation of water from a free water surface into the atmosphere directly, or through dry porous material, either soil or sand, was shown to be a linear function of saturation deficit. The rate of evaporation varied with the porosity of the material, but was not affected by its hygroscopicity. As much water passed from a free water surface through dry coarse sand as through dry coarse granular soil of identical permeability coefficient. The size rather than the quantity of pore space determined the extent of water lost. Cracks in a soil mass seemed to allow very rapid vapour movement.

The evaporation of water from a wet mass of soil when not more moist than the field carrying capacity, seemed to follow all of the laws of vapour movement. No evidence for capillary factors could be found. As much water was lost from wet soil columns when they were broken by air gaps as when they were continuous.

24. *With the aid of a careful technique a critical investigation has been made of the hygroscopic coefficient of soil at five temperatures, ranging from 15°C. to 35.6°C. It has been shown that (1) the customary 12-24 hr. period used by previous workers is much too short to give any approach to final values; (2) at the lower temperatures all except very light soils continue to take up water almost indefinitely, and it is not possible to extrapolate to an approximate final value; (3) these final values decrease with increasing temperature but in the early stages the rate of moisture absorption increases with increasing temperature; (4) the disputes as to whether the hygroscopic coefficient increased or decreased with temperature were due to the unrecognised operation of the effects detailed in (1) and (3) above.

From a careful survey of all the data obtained in the present experiments the conclusion is drawn that the hygroscopic coefficient cannot be satisfactorily determined even when the technique is refined considerably beyond that reasonably possible in routine determinations. This conclusion is supported by the results of vapour pressure determinations of moist soil, and by consideration of the manner in which colloidal material of a reticulate structure takes up water vapour. Attention is again drawn to a suggestion in an earlier paper that a measurement of the moisture content of

soil

soil in equilibrium with an atmosphere of 50 per cent. relative humidity should replace the hygroscopic coefficient. The proposed determination can be quickly and accurately made; it is only slightly affected by temperature changes, and it has the further advantage that it closely corresponds to a definite point on the vapour pressure curve - the point of inflexion.

25. * Application of fertilisers in the hill increases the osmotic pressure of the sap of young corn plants, which in turn lowers the freezing temperature of the plant from one to two degrees centigrade. This is often sufficient to prevent plants from being frozen by late spring frosts when they are not too severe. When the temperature falls slightly below freezing, further decrease is retarded due to the heat produced by the freezing of free water and easily frozen plant material. Usually enough heat is liberated to prevent the temperature from falling more than one or two degrees below the freezing point. Under these conditions properly fertilised corn plants are not frozen. Because of this action of fertilisers, there is an added reason for the use of fertilisers in northern latitudes with certain crops which are grown on soils subject to late spring frosts. The greatest benefit in this way from the use of fertilisers will undoubtedly occur on peats, mucks, poor sands, and any other soils of low soluble salt content.

26. This pamphlet is a study of meteorological observations carried out in the twelve years 1912-1923 in the Argentine wheat zone. Rainfall data from 37 stations and temperature data from 13 stations in 5 provinces are given, together with areas of wheat sown and harvested and yields in these provinces over the period. The conclusion is drawn that the probable yield of wheat in the Argentine wheat zone can be calculated with an appreciable degree of accuracy from the meteorological conditions of the preceding winter - between the months of April and August.

27. * The information available regarding the climatology of cotton is not very extensive. The northern limit of the American cotton belt follows closely the temperature line of 70°F. for the growing season, whilst the western limit is approximately the line of 23 in. average annual rainfall.

Temperature conditions during the cotton growing season in Rhodesia are, however, very different from those prevailing in the American cotton belt, in that there is a marked fall in the temperature here during the latter half of the season, whilst the reverse is the case in America. For this reason it is probable that a higher mean temperature than 70°F. may be required.

In spite of the diversity of the temperature conditions under which cotton is grown the mean temperature during the month or so just prior to the commencement of picking is in all cases near 70°F. This condition can only be fulfilled in Rhodesia in localities which have a mean temperature of over 72°F. during the growing period. It appears probable, therefore, that the isotherm of 72°F. will represent the lowest temperature limit for cotton in this country.

In

In the 1923-24 season commercial yields of cotton were obtained in many cases with a total seasonal rainfall of only 15 in. As the standard deviation of Rhodesian rainfall is about 7 in. the normal rainfall line of 22 in. annual rainfall has been adopted as defining the rainfall limit of the probable cotton belt in this country.

It is an almost invariable rule in this colony that excessive rainfall seasons are associated with lower mean temperatures, whilst deficient rainfall seasons are associated with higher mean temperatures than the normal. The effect of the varying rainfall seasons will therefore be to restrict or enlarge the area embraced by the 72°F. isotherm. The limits would also be affected in certain seasons when good early rains are experienced, which would permit of planting in October or in certain limited localities where it is possible to plant early under irrigation. In addition, the introduction of a variety of cotton with a shorter growing period would materially affect these limits.

28. The development of an insect has, until recently, been considered in direct relation to the surrounding temperature only. W.D.Pierce has lately worked out the relation to the combination of surrounding temperature and air humidity. For a few of the most important insects in medical entomology the experimental data have been determined, but in agricultural entomology nothing has previously been done in relation to the effect of humidity, temperature only being considered. The theory that the product of temperature in degrees centigrade and time of development in days in constant, proved to be wrong, but has recently been corrected by Blunck, whose formula is: "The product of duration of development and the difference between the surrounding temperature and the critical cold-point is constant". The time of development in relation to the surrounding temperature forms an equilateral hyperbola. If for each of two temperature points of this hyperbola the corresponding duration of development is known, it is possible to construct the whole hyperbola, and for any other temperature point between the critical heat and cold-point the corresponding duration of development is known. This rule is illustrated by examples from the seasonal history of Ceratitus Papitata. From data from Hawaii and Italy it is known that the duration of development is 20 days at 26°C. and 41.7 days at 19.5°C. With these facts it is possible to construct the equilateral hyperbola. The critical cold-point for C. capitata is 13.5°C.; the application of the hyperbola to the countries that are, or may be, infested by the fly is shown in tables. At Plymouth, for example, the development of the summer generation would last from mid-June to the beginning of October, but the temperature of the first half of June (16.8°C.) is not sufficient, considering the average temperature of 8.1°C, in the other months, to make possible a winter generation. The acclimatisation of the fly in England is therefore practically impossible. In sub-tropical and tropical countries where, from spring till autumn, all stages of the fly are found together, it is impossible to fix the development data exactly to the day; it is only possible to give opinion on the most likely possibilities of development of C.capitata under given climatic conditions, and thus to provide a good basis for observations. The countries infested with C.capitata may be classed as those where permanent acclimatisation is impossible (as in England); those where the fly is permanently established, but where the continuation of generations is interrupted by a duration of development of at least 100 days in the winter generation, and those where the generations follow each other

without

without interpolation of a winter generation (that is, where the average temperature is never below 13.5°C.). The possible application of Blunck's rule in other cases should be examined, for if its usefulness were proved, it would afford a very important and simple basis on which to work in any country.

29. Drought periods have frequently been suggested as the most important single factor influencing outbreaks of bark-beetles. Outbreaks of the southern pine beetle, Dendroctonus frontalis, Zimm, are characterised by from one to three years of intense activity with longer intervening periods during which the insect is extremely rare. Three widespread outbreaks occurred in so-called drought years, in West Virginia in 1891, in South Carolina in 1911, and in south-western Virginia in 1921. With some of the western species of Dendroctonus the transition from endemic to epidemic status is not so marked, and annual surveys on the same forest over several years are required to obtain definite data. In order to determine if any relation exists between the occurrence of D. frontalis in destructive numbers and deficiencies in rainfall, all outbreaks since 1890 have been tabulated and compared with the precipitation records, and with the exception of two outbreaks in Virginia in 1922, when excessive rainfall was recorded, every outbreak occurred during periods of rainfall deficiency. Many observations indicate that these outbreaks originate locally on the higher points of southern exposure or drier situations from which the beetles spread as they increase in numbers. Late summer and autumn deficiencies seem to be more important than those at other seasons, and heavy precipitation during the periods of attack and brood development seem to be most effective in killing the beetles and the young larvae beneath the bark of the attacked trees. Preliminary observations and experiments with felled, girdled, fire-scorched and defoliated trees indicate that the greater susceptibility of trees during drought periods and the destruction of the broods with increased precipitation are the results of the varying water content of the trees.

30.* (1) In a pig on a diet badly balanced particularly with respect to phosphorus, calcium and magnesium 1 hr. irradiation daily for 24 days with a carbon arc lamp definitely increased the calcium and phosphorus retention as compared with a control animal kept in the dark. The balance curves for these minerals tended to approach each other in the light period and run a parallel course.

(2) Following upon irradiation the calcium and phosphorus in the urine rose, both actually and relatively to their excretion in the faeces, suggesting an increased absorption from the gut or a decreased excretion.

(3) The above results took place in the irradiated pig without any concomitant increase in body weight. This would indicate that a stimulus to calcium and phosphorus retention does not necessarily involve a stimulus to growth in general.

(4) In pigs on a satisfactory diet, well balanced particularly with respect to calcium and phosphorus, darkness, diffuse light (through glass) and irradiation of 1 hr. per day for 52 days caused little difference in the calcium and phosphorus retention, though such difference as there was, was in favour of the irradiated pig.

(5) In the irradiated pig on a week balanced diet no tendency was observed for the urinary calcium and phosphorus to increase after irradiation.

(6) Analyses of the bones were in general agreement with the findings of the metabolic analyses.

31. In three balance experiments on lactating goats it was found that irradiation of the animals by the carbon arc lamp reduced the loss of calcium from the body.

Leaving out of consideration the amounts contained in the milk secreted, the reduction was entirely accounted for by decreased excretion in the faeces; the urinary excretion remaining practically constant.

It is suggested, therefore, that irradiation by the carbon arc lamp caused an increased absorption of calcium from the intestine.

32. Data have been recorded over a period of 14 years (1911-1924) for flocks of two breeds of sheep (Cheviot and Blackface) kept under identical conditions (hill) during that period; these have been compared with meteorological records for the same time. Most suggestive associations between climatic conditions and fertility have been demonstrated, and also indications of differential response of the different breeds to climate. Thus it was found that the mean temperature at tupping time has a greater influence on the total yield of lambs than the mean temperature at lambing time; and that the latter has a greater influence in the case of the Cheviot than in the Blackface. Grouping together barren ewes, ewes which aborted and those which after lambing were unable to nurse their lambs, it was found that the influence of mean temperature on the proportion of this group to the number of ewes put to the ram is greater in the Blackface than in the Cheviot, while there is a suggestion that the mean daily range of temperature at tupping time has an inverse effect on the total yield of lambs for both breeds. The data suggested that the number of rainy days and the rainfall in inches at lambing time are associated inversely with yield. It was also possible to draw the tentative conclusion that climatic factors have no effect upon the sex-ratio as observed at castrating time.

33. 96 Light Sussex pullets were divided into two flocks and managed in the same manner for 52 weeks except that in one case the house was artificially lighted for 1¼ hr. each evening from 8th October until 24th March, and a small scratch feed was supplied at the time. Electricity from the house supply was used for lighting; 2 50 candle-power lamps were suspended 5 ft. from the floor and in addition 2 5 candle-power lamps were employed as dimmers. The large-powered lamps were kept burning from 8.30 p.m. to 9.55 p.m., when the dimmers were automatically brought into play; the latter being suspended 2½ft. above the perches and only used for 5 min. each evening to enable the birds to find their roosts after the main power was switched off. During the period when the test house was lighted at night an extra feed of grain was provided amounting to 1/3 oz. per bird per day.

The

The effect of lighting the house was to increase the output of eggs during the winter, as the average number of eggs laid by the test flock during the first 12 weeks was 61¼ as against 34¾ laid by the control flock. The annual production was only slightly increased; viz. by 12¼ eggs per bird. The cost of the additional feed amounted to 6¼d. for the year, whereas the increase in egg value was 5s. 1¾d. per bird; an increase in gross returns more than sufficient to pay for the extra cost of labour and lighting.

34. Studies of soil temperatures under various crops and on fallow land receiving irrigation are reported.

It was found that the effect of irrigation is determined mainly by the temperature conditions of the soil immediately prior to irrigation. If the surface soil temperatures are higher than those of the lower layers, increases in temperature of the lower layers take place on irrigation and vice versa. The temperature effects of irrigation are attributed to the displacement of the water already present in the soil by the addition of irrigation water to the surface.

The effect of rain upon soil temperature is shown to be similar to that produced by irrigation water, but not of the same magnitude, owing to the different rates at which the water is placed upon the surface of the soil. It is also shown that the conductivity of the soil is increased by irrigation. The suggestion of Keen and Russell, that the diffusivity of soil increases to a maximum with increasing moisture content and finally decreases as the moisture content is further increased, was confirmed.

35. Experiments with alfalfa, maize, wheat and sugar beet are said to have indicated a maximum yield of all these crops when the soil was maintained at a moisture content of from 20 per cent to 25 per cent of saturation. The greatest efficiency in the use of water closely approximates the point of maximum yield.

36. (1) *The results of experiments on the rate of horizontal flow, and on the rate of gain in mass, of kerosene and of water in fine and crumb fractions of certain West Indian colloidal soils, comprising three siliceous soils containing different amounts of calcium carbonate, and two lateritic soils, are described and tabulated.

(2) The methods of experimentation employed were those elaborated by Green and Ampt, whose equations were found, however, not to fit the values obtained, as is to be expected.

(3) The siliceous soils examined possess relatively high swelling coefficients, and their component particles, when wetted, cohere to a greater or lesser extent, depending on lime content. These properties appear to account for the relatively low rates of permeability to water in these soils. Lateritic soils, on the other hand, possess low swelling coefficients, and low cohesiveness, water percolates through them relatively very rapidly.

Using

37. *Using the conception of the "ideal soil" a calculation has been made of the cohesion due to the capillary attraction between the particles when wetted. Experimental verification of this theory is afforded by cohesion tests on the ignited silt fraction separated from soil.

38. In the United States, from the modest "Signal Corps of the Army" of 50 years ago, the imposing Weather Bureau of today has developed. In spite of the demands of financial policy for economy, the activities of this institute have been left untouched.

The public displays a general interest in the reports of the Weather Bureau, both in the Annual Report and in the popular weekly reports, viz:- the Weather and Crop Bulletin published by the Central Bureau and the Corn and Wheat Region Bulletin published locally, while the daily weather reports find numerous readers. It may here be remarked that in the Union 230 weather report and forecasting stations operate. The scientific works and the year books have a very large circulation. It is not to be wondered at, therefore, that the public fully realise the aim and work of the Bureau, and find not only cultural but economic utility therein.

As regards forestry, the woodlands are watched over by aircraft to protect them from forest fires, and since July, 1924, the aircraft of the transcontinental aerial post has also participated in this service. In addition, during the dangerous period of the year two expert meteorologists are always in readiness in the forest district.

Forecasts are prepared in the morning and are promptly issued by wireless, telephone and railway letter. So it is with the reports of the various warning services, which cover every possible economic branch, even bee-keeping having the protection of a warning service. That the most important branches of rural economy are well looked after is evident from such protection. Fruit and vegetable growers are in close touch with the stations throughout the whole year, from the commencement of sowing, through development and ripening up to transport and utilization.

It is not only the producer who depends directly on the weather who derives benefit from meteorology; Industry also often calls upon the weather service. As an example may be mentioned the fight of the miller against the Mediterranean flour moth. In the present state of knowledge the only possible way of eliminating this pest is by the application of cold. The usual procedure is to stop the whole mill, empty all water from the boilers, piping etc., and expose the whole place to the severe winter frost (-12°C to - 7°C). When this operation is to be carried out naturally only the district weather station can forecast or

suggest

suggest. This method of elimination has been in use for twelve years with general satisfaction.

39. In a previous publication the author showed that incipient ice formation in an apple fruit did not result in any visible change of colour in the cells, but that even slight freezing increased the granular texture and insipidity of the fruit, as well as its susceptibility to fungus invasion. Such apples appeared to break down rapidly in storage. As a further contribution to knowledge relating to the effect of freezing on apples, studies were made on the respiration of the fruit to determine the nature and extent of injury in variously frozen apples.

Winesap apples frozen for 3 hr. and for 6 hr. after ice formation at air temperatures of from -7.5°C to -8.5°C., when measured at 0°C. increased their respiration as much as 85 per cent. above the previously determined normal performance. This acceleration lasted for several days, gradually declining, but it was still evident one month after treatment. Winesap apples frozen sufficiently to kill four-fifths of the cells, at 0°C. excreted only about one-third of the amount of carbon dioxide which they had formerly produced as normal, unfrozen fruit. The same variety of apples frozen for 3 hr. and for 6 hr. after ice formation, when measured at 20°C. increased in respiration in a manner similar to that at 0°C, although generally with a smaller percentage gain. Apples frozen for 6 hr. and then held at 20°C. soon become invaded by Penicillium.

Baldwin apples frozen for 3½ hr. gave the characteristic increase in carbon dioxide when measured at 0°C. McIntosh apples, when frozen for 3 hr, 6 hr and 9 hr. showed almost an equal respiratory response at 0°C. When measured at 20°C., the frozen McIntosh fruits gave a significant rise in respiration at 3-hr. 6-hr. 9-hr and 12-hr exposures. With one exception, the gain following a freezing treatment was somewhat less than in the other measurements. McIntosh apples frozen for 21 hr. at which time all the cells were killed, gave off 87 per cent less carbon dioxide at 20°C. than they had previously given off as normal, unfrozen fruits.

40. *At this Institute unique provision has been made for the control of a large number of environmental factors governing plant growth. The advantage of exercising such control is equally patent from the standpoint of the entomologist who, in so far as the agricultural aspect is concerned, needs to study pests in close relation to their hosts.

It may be mentioned that the laboratory service in this Institution includes hot and cold water, distilled water, high pressure steam, compressed air, vacuum, gas, refrigerated brine, electricity and exhaust and ventilating ducts. Each laboratory is provided with a shower head over each door, with a tap at the side of the door, for extinguishing fire in the clothing of a worker in case of accident.

There are four ranges of greenhouses which run east

and

and west and are separated from each other by 5 ft. alley ways. Each range is subdivided into four houses thus providing for a wide scope of controlled experimental conditions.

Temperature controls can be exercised within very narrow limits. High temperatures are maintained by electrical heating and low temperatures by refrigeration, while the two are combined for moderate degrees. Calcium chloride brine at a temperature of 0°F. is conveyed from the refrigeration plant (of the ammonia absorption type) through insulated pipes to the refrigerator room and to many small installations in the different laboratories. A part of the ammonia compressed by the plant is also used in cooling water for humidity and temperature controls in various parts of the building.

Constant condition light and dark rooms 11 ft. square are located in the basement. The light room is supplied with 25 1,000 watt lamps suspended from the ceiling and the intensity is of the order of 400 foot-candles. A ray filter consisting of a sheet of glass over which water is continuously circulated is interposed between the lights and the growing plants, in order to afford protection from heat rays. Mercury-vapour lamps can be interposed in order to supplement the tungsten lamps which are poor in blue and violet rays. In both these rooms temperature can be controlled to within 1°F. and humidity to within 2 per cent.

Two of the greenhouses are equipped for auxiliary lighting by means of 48 1,000 watt lamps. This enables an investigator to lengthen the daylight period if required.

5 spectral glass-houses render it possible to test the effects of eliminating certain portions of the spectrum. These houses are as follows: 1. Ordinary glass which absorbs the shorter ultra-violet rays. 2. Transmits all visible and most of ultra-violet rays. 3. Transmits no ultra-violet rays. 4. Absorbs the ultra-violet and blue rays, transmitting the longer rays. 5. Transmits only a portion of the green and all the yellow and red rays.

A range of greenhouses is fitted with controls for humidity and temperature. Metal ducts convey humidified air from a humidifier in the basement and another system of ducts returns the air to the humidifier. Air is saturated in a tank with water vapour at a given constant temperature and is then heated by steam to the desired greenhouse temperature as it passes through the delivery ducts. Air thus conditioned is recirculated every 2 min. humidity being controlled to within 2 per cent and temperature to within 1°F.

Carbon dioxide plant is being used to determine the optimum concentration of CO_2 for the growth of various plants. The installation consists of 4 glazed tile towers, a pump for circulating sodium carbonate liquor and a fan for removing flue gas. If the first 2 towers the gas is scrubbed with water and in the other 2 with sodium carbonate solution. The gas is then driven into the experimental houses concerned.

A defect of the process is the difficulty of eliminating all noxious gases and additional towers have been erected for scrubbing purposes.

The temperatures and humidities of all the different chambers are recorded at a single central station.

41. This is the third of a series of observations on temperature and moisture conditions, with particular reference to plant and animal life in the Wady Digla, a desert ravine about 200 ft. deep, 300 yds across at the top, and 80 yds. across at the bottom. The early observations, previously noted were made in August, 1922, at the hot, dry time of the year and in March, 1923, at the cold dry time. In the study here reported, the observations were repeated during 7½ days in December, 1923, when the temperature was about the same as in March but the moisture considerably higher.

Summarizing the results, which are reported in detail and recorded in graphs, the author concludes that "the air shade temperature ranges for an average year from below 5°C. to above 40°C perhaps occasionally reaching 0°C. and occasionally 45°C. The mean daily range, however, is not as great as one usually associates with desert conditions ..... The surface ranges in temperature from about 60°C. to about 5oC. or lower during the year ..... The daily range is 30°C. to 35°C. when the sand is fully exposed to the sun, but it is much less when it is partially shaded at any time of the day. The mean temperature of the sand at a depth of 30 cm. is 33.5°C. in August, 19.7°C. in March, and 17.1°C. in December. These are the greatest extremes that need be encountered by an animal that can burrow to this depth, and are only slightly greater than the daily air range on a summer day. In summer the temperatures are higher, the daily change of temperature is greatest, the daily change of humidity is greatest, and the evaporation is nearly three times that in December. In addition there is no rain and only rarely dew. These are the conditions most inimical to plant and animal life in the open."

In winter vegetation increases, followed by increase of insect life in spring, which is largely cut off by succeeding hot weather. No particularly striking change of air temperature at sunset was observed.

Appendices give lists enumerating over 200 species of birds, insects and plants observed in the vicinity of the observation camp.

42. *Nearly nineteen hundred years ago the Romans were attempting to protect their vineyards from damage by frost by building smudge fires. This method is still in use in some parts of the United States, although careful experiments have demonstrated that a smoke cover alone affords little protection.

Apparently,

Apparently the first actual orchard heating, as distinguished from smudging, was carried on in orange groves during the years 1897-1899. Coal baskets made of large mesh heavy wire were set in the orchards at the rate of 40 baskets to the acre. Good results were obtained.

The use of oil-burning orchard heaters on a large scale appears to have begun about 1905. They were at first simply open pans, which gave off large quantities of black smoke and soot.

Some 10 years later the stack heater began to make its appearance. These heaters burn with practically no smoke when carefully regulated, but when hundreds or thousands are burning together on a cold night, with little or no careful regulation, considerable smoke results.

When the Weather Bureau fruit-frost service was begun in 1917, orchard heating was in bad repute, due to the use of poor equipment, too few heaters to the acre, inaccurate thermometers, etc. During recent years, however, the protected acreage has increased by leaps and bounds. During the winter of 1924-25, there was so much orchard heating that considerable objection to the smoke and soot resulted. Improved smokeless methods of protecting the fruit are therefore being sought.

Machines have been placed on the market devised to keep the air mixed to a considerable height above the ground and prevent stratification. It would have been a simple matter to demonstrate theoretically that these machines had no hope of success, but a thorough field test was necessary to convince the growers.

Another type was designed to discharge a current of heated air over the tops of the trees. These machines failed owing to their inability to spread the heated air over a large enough area.

During the past two years several growers have installed overhead sprinklers, for irrigation and frost fighting combined. During the winter of 1924-25 a careful check on the effect of this artificial rain was made under actual frost conditions. The temperature was raised about 3°F. but it was necessary to shut off the water after about 2 hours, because the heavy coating of ice threatened to strip the branches from the trees.

Other new devices tested may be mentioned. First is the central heating plant. The fuel was burned in a large furnace, and the heated gases driven through large pipes through the orchard. Second is the covering of the trees with canvas tents. Third is the running of irrigation water in furrows in the orchard. In a carefully conducted experiment it was found that running water at a temperature of 72°F. in an orange grove held the temperature about 1.5°F on the average above the outside temperature. Fourth is the use of coal briquets for orchard heater fuel.

To sum up, the orchard heater is to-day the only practical means of obtaining complete protection from low temperatures in orchards, but constant effort is being directed towards finding some more satisfactory method.

Experimenters

43. *Experimenters are not fully agreed as to the importance of the tillering ability of cereal plants. Some have considered scant tillering an advantage as the secondary heads sometimes produce but little grain and that of light weight and poor quality. Others have found a positive correlation between tillering and yield and conclude that cereal varieties of high tillering ability are likely to be good yielders. Still others find but little relation between tillering and yield and consider that the extent of tillering is not an index of yielding ability.

Data obtained from 3,000 observations on 64 varieties of spring wheat, oats and barley at the Dickinson sub-station during the years 1909 to 1919 gave results as follows:-

(1) In a comparison of varieties of a crop there was no uniformly close relation between extent of tillering and yield.

(2) In a comparison of groups of crop varieties, durum wheats yielded more but tillered less than varieties of common wheat of the Bluestem group. Four groups of oats were about equal in extent of tillering, but the two mid-season groups outyielded the early and late groups. The two-rowed hulled barleys yielded more and tillered more than the six-rowed hulled groups, and the latter exceeded the six-rowed naked group in both respects.

(3) Comparing the three crops, oats yielded most and tillered least, and barley slightly exceeded wheat in both tillering and yield.

(4) Comparing different years, mean tillering, mean yield and rainfall from May 16 to July 15, all are closely correlated, showing the close relationships that exist between rainfall and tillering and between tillering and yield.

(5) During dry seasons tillering ability was relatively unimportant, the number of heads per plant being approximately 1 in all varieties. In seasons of abundant rainfall tillering ability enabled the plants to respond to the moisture conditions and as a result to produce larger yields.

44. *There can be little doubt that the weather of 1924 was responsible for the absence of pests in that year. From the point of view of the insect, lack of sun and continual rainfall are undoubtedly inimical to such pests as aphides and caterpillars; from the crop standpoint, the absence of any condition which causes the plants to stand still - such as a drought - greatly favours their escape from insect pests. No such arresting period occurred in 1924, which therefore was a year favourable to the crops, while unfavourable to insect pests, and the absence of epidemics was natural.

As regards 1922, it is again not difficult to suggest a connection between the weather and the epidemics of Frit and Gout Fly upon oats and barley respectively. In the case of these crops and pests, the critical period is from

about

about the 1st March to the end of the first week in June. During March, April, and part of May - before Frit and Gout Flies have emerged - the plants can make their growth unimpeded, and if weather conditions are favourable, they should, by the time the flies appear, have reached a stage at which they are no longer very susceptible to Frit or Gout Flies. If, on the other hand, the weather is unfavourable to growth, the crops are retarded and are in their most susceptible stages when the maximum number of flies are out. Again, the flies are also to some extent affected by the weather, for though (in the case of the Frit Fly at least) the times of emergence from the pupae do not seem to vary much, nevertheless, in cold, wet weather, the activity of the insects in egg-laying will be reduced, and in bright, warm weather will be encouraged. If these considerations are applied to the year 1922, it will be found that from the second week in March to the second week in May, temperatures were almost continually below normal, often much below, and vegetation generally was backward. Growth of oats and barley was naturally impeded. On the other hand, from the third week in June, just when the maximum prevalence of the Frit Flies might be expected, temperatures were consistently above the average with continual bright sun and less rain than the normal. Conditions, therefore, in 1922 were definitely in favour of the flies and equally against the two crops concerned, with the natural result that damage was abnormally great.

In the case of the 1923 outbreak of fruit tree caterpillars and aphides, it is less easy to suggest correlation between weather and epidemic, but certain facts are suggestive. Reports indicate that not more than the normal number of the pests concerned were hatched from the egg. Many experienced reporters, even as late as May, suggested that aphides were in smaller numbers than usual and tending to disappear. Yet by the second week in June irreparable damage had been done. Evidently, therefore, the weather conditions in May or June were of importance, and it is interesting to find that during practically the whole of these months the temperatures were abnormally low - the Meteorological Office describes May as "decidedly cool and dull, almost wintry" and refers to "showers of rain, hail, sleet and even snow". It seems possible that such weather may have held back the fruit tree foliage and while checking the aphides, as recorded by several reporters, nevertheless, left a sufficient stock to increase rapidly as the weather got warmer in June (even though it remained cooler than normal). The caterpillars, which are fairly resistant to cold, would not have been expected to suffer so much as the aphides from bad weather, and the result may have been that by the beginning of June there was a normal supply of caterpillars and aphides, but a shortage of fruit tree foliage. The fruit trees, unable to produce foliage as rapidly as the pests devoured or crippled it, were thus beaten in the race and suffered very serious damage, the results of which persisted not only throughout 1923, but even in many cases also through 1924.

Time alone, of course, will show whether these suggested correlations between weather and pest epidemics hold good, and it is only their important bearing upon the practical control of the pests concerned that justified speculation upon such relatively slender material as is yet available.

It

45. It has been considered doubtful in East Prussia whether delayed sowing in autumn of winter cereals is not advisable after a severe summer infestation by the frit fly (Oscinella frit). Data collected from 1921 to 1925 show that an abundance of adults in spring does not necessarily imply that the flies will be very numerous in summer. Their numbers depend on the weather in May, July and August, (the flight-periods of the three generations) hot, dry weather favouring development, though shortening the life of the adult. Heavy, repeated rains injure the flies and cause the flight period to end prematurely. These effects are more particularly noticeable in the last generation. A heavy infestation of summer crops does not therefore necessarily involve a prolongation of the flight-period in autumn. The duration of the flight of the lastgeneration is probably determined chiefly by the weather in September. If the weather is warm the flies will probably die at the usual date, and the winter rye can be sown at the usual time. This will also hold good if heavy rain and storms occur in the first half of September. If September proves cool and dry, a prolongation of the flight-period may be expected.

46. *Although the weather is beyond the control of the bee-keeper, a knowledge of the influence of weather factors upon honey crops in various parts of the country will be of great value in developing the best bee-keeping regions.

To gain this knowledge it is first of all necessary to keep certain colonies under observation, recording at frequent and regular intervals the weight of each, and recording such accompanying phenomena of the weather as may reasonably be supposed to influence either the secretion of nectar by the plants or the activities of the bees engaged in gathering nectar and pollen.

A confirmation of the practical value of carefully kept records of this sort is shown by their use in computing predicted changes of colony weight.

A mathematical analysis is necessary to show the true relationship between these changes and the attendant weather factors, and without such mathematical analysis the relative importance of various weather factors upon the changes cannot be shown.

Correlations were made during the spring honey flows of 1922 and 1923 at Somerset, Maryland, between changes in weight of a colony of bees and daily variation in temperature, relative humidity, hours of sunshine and solar radiation. By use of the formula for multiple correlation, exact response to changes in weight of the colony to changes in each of these weather factors was calculated.

From these calculations the exact weight was given to each of the weather factors considered. A variation from the average temperature was thus noted to have either a positive or a negative effect upon the weight of the colony which in turn could be expressed in terms of grams depending upon the number of degrees the temperature varied from the average. For

example

example, when the daily temperature was 4° above the average, there resulted from this an increase in colony weight of so many grams due to this one factor alone. Although the other weather factors were constantly affecting the weight of the colony, at the same time, the results attributed to temperature, for instance, represent that factor alone since corrections were made in each case for the effect of other factors. A quantitative as well as a qualitative analysis was made for all the weather factors enumerated above.

47. *The statistical data presented indicate that under Ohio conditions an increase in clover yields does, within limits, follow.- (1) An increase in total rainfall for the months of April, May and June. (2) An increase in cloudiness for the months of April, May and June. (3) An increase in total snowfall. (4) An increase in temperature for the months of March and April and a decrease in temperature for the months of May and June.

48. *The results obtained from this experiment confirm in almost every detail the conclusions drawn from the experimental work carried on during the winter of 1921-22. The depression of the temperature due to the presence of the cover crop was somewhat greater in the latest experiments, but this was to be expected, since the area in cover crops was larger.

It is believed that the results obtained in the two experiments conducted in different orchards and during two frost seasons, are reasonably conclusive, since they agree closely. Cover crops do increase the frost hazard, but only to a slight extent. In many cases the increased damage in presence of a cover crop is probably due to the fact that the grove is on lower ground, where the temperature is naturally lower. In other cases the increase may be accounted for by the small temperature differences which have been found in the experimental work.

Actual differences in the amount of damage between clean cultivated groves and those in cover crops, which can not be explained by the differences in temperature found in the two experiments, must be attributed to some other influence than temperature, such as decreased vigour of the trees, due to competition from the cover crop, a less dormant condition of the trees caused by more frequent irrigation, or increased deposit of moisture on the fruit and foliage from dew or frost, when a cover crop is present in the orchard.

From a study of all the experimental data it appears that the difference in temperature between a clean cultivated citrus grove and one in cover crop, especially during the earlier part of the night, is largely due to the cover crop acting as a windbreak, allowing the cold air to accumulate near the ground, and preventing it from mixing with the warmer air above.

The

The condition of the surface soil with regard to moisture content was radically different during the two seasons when the experimental work with cover crops was in progress. During the winter of 1921-22 the ground was wet throughout the season, while it was unusually dry throughout the 1923-24 season. The results obtained should therefore be indicative of all seasons, whether wet or dry.

49. A study extending over 10 years of the meteorological conditions prevailing during (a) 3 days, (b) 10 days, prior to an epidemic of potato blight (Phytophthora infestans) and (c) the critical period (May to September) revealed no definite or constant correlation between such factors as the frequency and amount of rainfall, vapour pressure, relative humidity and temperature and the moment of outbreak. Probably the influence of all these factors combined is too complex to be revealed by an analysis of each. In any case, there is apparently no correlation in Holland analogous to that existing in certain countries between weather conditions and the incidence of Plasmopora viticola.

The percentage of diseased tubers was much lower when the potatoes were lifted after a few days dry weather than after a corresponding wet period. Tubers of susceptible varieties, therefore, should not be lifted when the ground is very damp. Wounded tubers left in the field for varying periods before storage showed no signs of healing after six days.

50. The Year Book of the United States Department of Agriculture for 1924 devotes some 100 pages to an article on Weather and Agriculture. In a general section at the commencement of the article the origin of weather is described with particular reference to cyclones and anti-cyclones in the United States and Canada. This is followed by a general account of the effect of climate on vegetation in the different parts of the World. A further section deals with the adjustment of agriculture to climate, soil condition and topography; and in particular with the effect of moisture and temperature on vegetation and types of farming. A general description is given on agriculture in the different climatic zones of the World. Climate and agriculture are next dealt with, with particular reference to the United States.

With regard to rainfall and crop growth it is stated that the minimum amount of rainfall needed for ordinary farming under favourable seasonable distribution is usually considered to be between 15in. and 20 in. of annual precipitation, but several modifying influences which have wide geographical variations must be taken into account. Among these are soil texture affecting its moisture retaining qualities, temperature and the rate of evaporation. Broadly speaking about 15 in. of annual rainfall may be considered as about the minimum amount necessary in the relatively cool climates where the summer mean temperature ranges around 65°F.; and 20 in. to 25 in. in warmer areas where the summer mean is 75°F. to 80°F.

Several

Several hundred pounds of water are necessary during the life of a plant to produce one pound of mature matter, which means that a plant such as wheat or maize, requires each day an amount equal to several times its own weight. On the other hand with a rainfall of 1 in. without loss by run-off, more than 100 tons of water is supplied to 1 acre of land. The water available for growth is the difference between the amount of moisture present in the soil and the wilting co-efficient, i.e. the moisture content of the soil at a time when the leaves of a plant growing in it first undergo a permanent reduction in their moisture content as a result of the deficiency in the soil moisture supply. There is a wide difference in the wilting co-efficients of soils as those of fine texture are much more retentive of moisture than those of coarser texture, but the wilting co-efficient for a particular soil is substantially the same for all crops.

As regards temperature it is stated that in general most cultivated plants remain more or less dormant in temperature climates during the months when the mean monthly temperature remains below 49°F. Spring wheat may be seeded with a lower mean temperature than any other major spring crop. Seeding usually begins in the Dakotas and in Nebraska when the normal daily temperature rises to 37°F. and in Minnesota and Wisconsin at 40°F. Next in thermal order comes spring oats, the seeding of which usually begins when the normal daily temperature rises to 43°F. Early potato planting begins at 45°F. and maize at 55°F. The planting of early potatoes for example usually begins in Northern Mississipi about 15th February and Northern Wisconsin 2½ months later - in each locality when normal daily temperatures rise to 45°F.

Maize. The climatic boundaries of the region of intensive production of maize in the United States are a mean summer temperature of 70°F. to 80°F., an average daily minimum summer temperature exceeding 58°F., a frostless season of more than 140 days in length and an annual precipitation of between 25 in. and 50 in., of which at least 7 in. should occur in July and August. The temperature requirements of different varieties of maize vary widely; some southern varieties require an average frostless season of 180 days in length and a mean summer temperature of about 80°F. Practically no maize is grown where the summer temperature averages less than 66°F. or where the night temperature falls below 55°F. The critical period in the growth of maize during which favourable weather usually assures a good crop, and unfavourable weather causes a small yield, is comparatively brief. The most important factor affecting yield in the great maize producing areas of the United States is rainfall, and July is usually the critical calendar month. The period from about the middle of July to the middle of August, however, has a greater effect on production than any other period of similar length. The available moisture for the 10 days following the blossoming stage is especially important, the yield varying more or less directly with the amount of moisture in the soil during this period, provided the latter is not excessive. High temperature and dry soil during the 10 days after blossoming have a very unfavourable effect upon the yield. Records kept for 27 years in Ohio show that maize comes up on the average in five days after sowing, with a mean daily temperature of 71°F., in 6 days with 67°F, 7 days with 66°F., 8 days with 61°F., 9 days

with

with 60°F. and when the mean daily temperature averaged 55°F. it requires 10 days or more for the plant to appear above ground. Cool wet weather immediately following planting is especially unfavourable, for with such conditions the seed may not germinate at all, or many of the young seedlings after germination may not have sufficient vitality to push themselves through the heavy wet soil. On the other hand, warm weather with a moderate amount of moisture usually insures a good stand. The best date to begin planting maize on the more favourable soils is about the time the normal daily temperature rises to 55°F. While temperature is usually more important in maize growth during the spring and early summer, thereafter rainfall is of greater importance. The correlation co-efficient between the June temperature and the 1st July condition of maize is + 0.65 for Ohio and +0.82 for Iowa. There is, however, a much closer relation between the June temperature and the 1st July condition, than between the June temperature and yield, as the latter depends more in most cases on the weather during July and August. When maize contains a large amount of moisture its germinating quality is much more liable to be affected by low winter temperatures than when the kernels are dry. With 10 per cent to 14 per cent of moisture it is usually safe from injury, but when it contains as much as 60 per cent the germ may be killed by a prolonged exposure to a temperature only slightly below freezing.

Wheat. Wheat may be successfully grown over a wide area of the earth's surface and in a variety of soils. The crop is best suited, however, to regions having a growing season of at least 90 days in length and moderate rainfall. It is most extensively cultivated at present where the average annual rainfall is less than 30 in.

Spring wheat is usually sown where the winters are dry and cold and winter wheat where it is warmer with more snow protection. The quality and chemical composition of wheat depend largely on the climate of the region in which it is grown. Wheat of the more humid areas has a tendency to be of soft and starchy composition, whereas that grown in less humid climates is hard and darker in colour. The ideal climate for wheat is one with a long and rather wet winter prolonged into a cool and rather moist spring which gradually merges into a warmer summer, the weather growing progressively drier as it grows warmer with only comparatively light rains after the blossoming of the crop - just enough to bring the grain to maturity. Wheat should have abundant sunshine and rather dry air, but without dry and scorching winds towards harvest, until the grain is fully ripe, and then warm, dry, rainless weather until the harvest is gathered.

Winter damage to wheat is usually grouped under four main headings viz. heaving, smothering, direct effect of low temperature, and drought. Heaving is one of the most common causes of damage especially on poorly drained soil; it usually occurs in spring and is due to alternate freezing and thawing which lifts the plant from the soil and leaves the roots exposed to the air. This is a common cause of winter killing in the Eastern United States.

Smothering of the plants occurs when the ground is covered with an ice sheet. Plants are sometimes killed by the direct effect of cold on the tissues when snow protection is absent.

The

The season of winter wheat growth from the time of planting to harvest is so long that it is difficult to determine satisfactorily the weather influence on the final yield during different periods of growth. It is important that the moisture be sufficient to enable the preparation of a good seed bed and for germination of seed, and that the early period of growth be moderately warm and moist. When favourable weather prevails during the autumn months the plants usually establish a good root system and are less liable to winter injury than when unfavourable growing weather prevails during that period. Statistical studies indicate, however, that conditions during autumn do not bear, in general, any material relation to the yield of wheat the following summer but that the weather during the winter, spring and early summer months, especially from March to June has a much greater effect in the final output. Wheat may be in poor condition at the beginning of winter and with favourable weather later the improvement may be such as to produce satisfactory yields. On the other hand, good growing conditions may prevail throughout the season until near harvest time when a short period of unfavourable weather may prove disastrous. Hot dry weather during the ripening period especially following a spring and early summer season of warm weather and abundant moisture is especially harmful.

The precipitation in May and June and the temperature in June are important factors in the growth of spring wheat.

Oats. Oats are best adapted to cool moist climates such as are found in most of the northern European Countries, the north-eastern portion of the United States and in Canada. The oat is a cool weather plant and consequently needs moderately low temperatures during the season when the heads develop and fill. Winter oats are less hardy than winter wheat and are more frequently damaged by cool waves in winter and they usually yield less than spring oats.

Spring Oats should be sown about the time the normal daily temperature rises to 43°F. or at the beginning of the general vegetation period. The crop requires nearly 4 months to mature and it is important to seed as early as weather conditions will permit so that the critical period in the growth will be reached before the warmest of summer weather sets in. For best results the temperature should be above normal for the season and locality about the date of sowing and for some time thereafter, with only moderately moist soil. When the heads are forming and grain developing, the crop requires cool and moderately wet weather, as such conditions favour proper filling and ripening of the grain. Hot dry weather even for only a few days at the critical period of development may materially reduce the yield.

It has been found in Russia that a mean daily temperature about 75°F. with a maximum above 86°F. between the heading and milk stage endangers the yield of oats especially if several such days occur in succession. An abundance of moisture in June when the plants were developing vegetative organs was found to be very beneficial.

Rye. A correlation of weather and yield of rye in the northern portion of the United States shows that the crop needs for best results moderately dry and warm weather in

April, a rather abundant moisture supply in May and cool weather in June.

Experiments in Russia indicate that favourable conditions include a rather plentiful supply of warmth and moisture before the formation of the heads and cool and damp weather thereafter, though with moderate temperatures and dry weather during the blooming period. The crop does not fill well if there is too much rain when the heads are in bloom.

Barley. The temperature range of this crop in the United States is wider than that of any other cereal. It will mature with an annual rainfall of less than 10 in. and is mostly grown in sub-humid to semi-arid climates. Although it can be grown in warmer climates the principal producing districts in the United States do not have any month during the growing season with a mean temperature above 75°F. It has been found in England that the chief requirement for a good yield is a cool summer, especially after mid-June.

Barley is affected by spring frost more than either wheat or oats but it recovers quickly from frost effect. A correlation of barley yield and weather in Wisconsin shows that the crop yields best with a rather warm and dry April and a cool June, with rainfall in May and June moderately above normal.

Weather and Crop Services.

A section of the article deals with weather and crop services in the United States. Special weather and crop services are maintained by the Department of Agriculture through which information on prevailing weather conditions and their effect on growing crops and farming operations is made available to all interested persons. For this purpose the Weather Bureau maintains two more or less distinct services, a daily one and a weekly one. Daily services are maintained in cotton, maise and wheat, sugar and rice regions. In these a large number of special meteorological observers well distributed throughout the principal agricultural sections of the country, make weather observations and their reports are collected by telegraph and published daily in bulletin form at designated Central Weather Bureau Stations in different sections of the country. These bulletins show for the various stations and for each 24-hour period the highest and lowest temperature, the general character of the weather and the amount of rainfall.

In the weekly service the officials in charge at designated Central Weather Bureau Stations for the several states collect information weekly from special and co-operative meteorological observers and a large number of correspondents relative to prevailing weather conditions and their effect on farming operations and crop growth. These officials make weekly reports to the Central Office at Washington where the information is tabulated and summarised into a Weather and Crop Report for the entire country. This is issued by telegraph each Wednesday at 10 a.m. and published in the "Weekly Weather and Crop Bulletin" which includes meteorological

tables

tables and charts showing graphically the precipitation and temperature conditions throughout the country. In addition there is published a local weather and crop summary at each State centre relative to conditions prevailing in the respective States.

The article concludes with sections on livestock and the weather, marketing and the weather (including refrigerator cars and cold storage), the weather and railroads, floods, and forests and the weather.

51. To determine the effect of different climatic factos on the rate of growth, Helianthus annuus and Zea mais were grown for a number of days and their rate of growth as well as their green and dry weights were determined. During the growth of the plants, records were made of the temperature, relative humidity, precipitation and total hours of sunshine. It was found that low soil temperatures retarded the germination of the corn and sunflower seed. A temperature 24-29°F. injured the corn. The growth of the 2 plants showed a greater correlation with temperature than with any single climatic factor. The corn plant seems to be suited to regions where the growing season is long, the temperature high, and the soil moisture limited; while the sunflower thrives best in regions of low temperature and abundant soil moisture.

52. *The date palm, Phoenix dactylifera, as represented by its horticultural varieties, has a wide range of temperature endurance, being able to survive without permanent injury temperatures in different localities from 4°F. to 125°F.

The geographical range of the date palm as a plant is very much wider than the range of its successful fruit production, and the cultivated varieties are often rather exacting in their temperature requirements.

Date trees, under favourable environment, continue growth throughout the year at a rate closely correlated with the current mean temperature. Growth may continue at a reduced rate when the minimum air temperatures are several degrees below the freezing point, provided the maximum temperatures of the days are well above a minimum of 50°F.

Observations at the United States date garden at Indio, Calif., show that with minimum temperatures above the freezing point but with the maxima of the days reduced to from 46°F. to 50°F., growth of four date palms, after a characteristic lag, has been found to have entirely ceased. A specific zero point or minimum temperature for growth of between 46°F. and 50°F., but varying slightly with the individuals, has been deduced from these records.

Young date palms in pots placed for 14 days in a controlled temperature bench in a greenhouse at a temperature varying but slightly from 53°F. made daily growth of from 0.5 mm. to 1.0 mm., and slight gains were recorded at from 49°F. to 50°F. Below 49°F. all growth ceased. The plants experimented with in the greenhouse cool chamber when placed in greenhouse benches at day temperatures of about 68°F. resumed their normal rate of growth in darkness without appreciable delay. The laboratory tests thus confirm the previous field observations.

The conclusion is reached that the zero point or minimum temperature permitting growth of the date palm, lies at from 48°F. to 50°F. for the actual region of cell division and growth, and that this knowledge is fundamental to the study of the reactions of these trees to other temperature conditions.

53. The date palm is the most resistant to extremes of heat and cold of any member of the palm family. As a species it has survived without permanent injury extremes of temperature from 4°F. to 125°F. This wide range of adaptability is believed to be largely due to the morphological structure and physiological action outlined in the following paragraphs:-

The date palm, along with other members of the palm family, has its active growing tissue centralised in a giant terminal bud or phyllophore from which are in progress simultaneously the basipetal or intercalary growth of leaves and flower spathes and the elongation of the trunk and its thickening to the established diameter.

Within favourable temperature limits, and with sufficient water supply, the growth of the date palm is continuous throughout the year, the curve of mean daily leaf elongation being closely parallel to the curve of mean daily temperature. Growth may be continued when the minimum air temperature of the day is several degrees below the freezing point, provided the maximum temperature of the day is well above the growth zero point, 50°F.

Thermometers inserted in date palm growth centres show a stabilizing of temperatures with a marked gradient between them and those of the surrounding air, but with a striking correspondence with the temperatures of the soil strata penetrated by the palm roots.

The daily range of these interior temperatures is slight and rarely exceeds 7°F. or 8°F., but with an inverted curve, relative to the air temperature curve, highest at about sunrise, lowest at from 2 p.m. to 4 p.m.

The difference of the interior temperature from the surrounding air has ranged from 26°F. warmer on the coldest morning observed, to 32°F. cooler on the hottest day.

This protective stabilizing of the temperature of the mersitematic tissues of the date palm is believed to be due to two principal factors as follows:-

(1) A protective envelope surrounding the growth centre, of a highly non-conducting and insulating nature, composed of the thick, fibrous, overlapping leaf bases, with the accompanying fibrous sheath and lower down the outer zone of the trunk proper. Through these layers the air temperatures, cold or hot, penetrate very slowly and with considerable loss.

(2) The ascending sap current, with a temperature acquired from the soil from which it is drawn by the roots. Under the insulation afforded by the protective layer and the outer portions of the trunk, the sap is able to reach the growth centre at a temperature varying but a few degrees from that at which it left the soil, and so is able to neutralize much of either cold or heat, as the case may be, that has penetrated from without.

It is believed that in the discovery of this stabilizing of the temperature of the growth centre of the date palm is disclosed a principle heretofore unrecognised in plant physiology, and one of vital importance to palms and other endogenous plants in desert environments in enabling them to survive the extremes of their temperature exposures.

54. Date palm leaves are formed from the top of the phyllophore or growth centre deep in the interior of the terminal bud, protected from light and from wide ranges of temperature.

The leaves, in groups of from three to five, called a palus are pushed forward by basipetal or inter-calary increment, no alteration in their length occurring after they reach the light and assume their green colour.

Normal growth, as made manifest by the pushing up of the leaves from the growth centre, is made chiefly in the time between sunset and sunrise, but also at a reduced rate in daylight, when direct sunlight is cut off by clouds. In full sunlight date palm leaf elongation entirely ceases.

Date palm leaf growth may be induced in darkness obtained by inclosing the plant in a dark chamber, at any hour of the day. Partial growth may be induced in a similar manner by screening the plant from direct sunlight, but giving it exposure to north or reflected light.

Growth begun in darkness was continued at practically the normal rate when the plant was exposed to a battery of Mazda electric lights giving brilliant illumination.

When date plants, after beginning growth in a dark room, were exposed to the rays of Cooper-Hewitt lead-glass mercury-vapour tubes, the inhibiting of growth was as prompt as in direct sunlight.

A spectroscopic analysis of the rays from Cooper-Hewitt lead-glass tubes shows that this light is confined to rays from the shorter wave lengths of the visible spectrum through violet, blue, green and yellow to about the line D (0.578 μ). The orange and red are completely absent.

It must be concluded, then, that the inhibiting of the date palm leaf growth in intense sunlight of the desert regions is due chiefly to the action of rays of wave length from about 0.57 μ in the yellow to about 0.405 μ in the violet end of the visible spectrum, but invisible ultra-violet rays probably assist in stopping growth.

Photosynthesis is most active in longer wave lengths from the line D at the end of the yellow to lines B and C in the red: thus growth is inhibited by light that has but little potency in photosynthesis and conversely carbon assimilation is favoured by light that has but little ability in inhibiting growth.

Growth in absence of direct sunlight is apparently synchronous with the closing of the stomata, checking of transpiration, and increased turgescence in the meristematic tissue.

55. The chief climatic factors influencing tree growth appear to be precipitation, temperature and sun radiation. The relative rôle of each factor is dependent on the time of its influence, upon other factors, upon internal conditions in the tree, upon earlier conditions in general, etc. Thus, growth can primarily follow now this, now that, factor. No direct study of the relationship has ever been made, so that not

even

even the general laws are known. In the case of the big tree the importance of the individual factors is much more difficult to estimate, as data of temperature are entirely wanting. However, it appears to be certain that the sequoia curves do not specially record precipitation. High parts in the curves might directly or indirectly be connected with periods of heavy rainfall and low parts with scanty rainfall, because of the relationship between the different climatic factors as influenced by the activity of the sun, so that trees in moist and dry sites might be favoured or checked contemporaneously by different factors, but it cannot be concluded that all high and low parts were connected with rainfall and drought. In this connection it is noteworthy that the tree-growth maximum during the 14th century coincides with an exceptional spottedness of the sun and with the climatic stress, of which there are abundant historical records in the Old World, and which particularly expressed itself in unusually cold winters, cold rainy summers, and devastating storms.

Accordingly, before satisfactory interpretation of the sequoia curves and conclusions from them regarding the climate of the past can be made, it is necessary to have data on temperature, better knowledge of the relation between precipitation and growth of sequoia trees in dry situations, and general knowledge of the rôle for growth played by radiation of the sun.

56. Experiments similar to those made with Aëdes were carried out in 1924 with Culex pipiens, L. The results indicate a close relation between the numbers of mosquitoes caught and atmospheric conditions such as temperature and relative humidity. This number is supposed to indicate the activity of the insects. The activity of C. pipiens is slight at temperatures below 70°F., but increases rapidly between 70°F. and 80°F. After 90°F. the activity decreases, until at 112°F. to 113°F. the mosquitoes die. The reaction of mosquitoes under laboratory conditions, with no chance of escape, corresponds with field observations. With regard to the relative humidity, the relation is positive up to 90 per cent., after which the activity seems to be accelerated up to about 95 per cent., followed by a sharp drop when the saturation point is approaching.

57. Repetition of a previous experiment has confirmed the beneficial influence of ultra-violet light in the prevention of leg weakness in growing chickens. Blood and bone analyses showed a higher calcium and phosphorus content in the case of the irradiated as compared with the non-irradiated chicks.

For egg production three groups of 12 Leghorn pullets received a similar ration of corn, tankage, casein,

butter

butter and bone-ash with sprouted oats supplied ad lib. Pen I. received ultra-violet light for 10 min. daily for 16 weeks; Pen II. was kept in a well lit room with no direct sunlight; Pen III. was kept outdoors exposed to sunlight. Before the experiment commenced no significant difference was found in the egg production of the three groups. The production during the 16 weeks of the experiment was as follows: Pen I., 497 eggs; Pen II., 124 eggs, Pen III., 617 eggs.

The beneficial action of light was also shown in the chemical composition of the egg: the weight of calcium in the shell and the percentage of calcium and phosphorus in the contents being higher in the irradiated pen and the pen receiving direct sunlight than in the pen receiving no direct light. Half the birds in Pen II. died during the experiment, all showing the symptoms of leg weakness.

The light treatment in Pen I. was discontinued and begun in Pen II., when the previous order of egg production of the two pens was reversed, while no further deaths took place in Pen II.

The eggs having the highest calcium content hatched best, but it was not believed that this was due to the percentage of calcium, but to a variation in the antirachitic vitamin content. Another factor believed to affect the hatchability is the amount of sunshine just preceding and during the time the egg is produced.

The above interesting results of irradiating birds fall into line with results previously obtained with mammals. The beneficial influence of sunlight on the health and rate of growth of young pigs was noted at the Rowett Institute in 1920, where pigs confined to a badly lit and badly ventilated sty failed to grow. Hess and his co-workers in America found that sunlight or artificially produced ultra-violet rays prevented or cured rickets, a disease of metabolism. Orr, Magee and Henderson (Proc. Physiol. Soc., 5/7/24) found that, in growing pigs on a diet badly balanced with regard to its mineral content, irradiation definitely increased the absorption and retention in the body of calcium and phosphorus.

58. The author studied the blooming period of plants growing on Mt. Tamalpais, California, where Weather Bureau records for temperature and moisture had been kept. He noted 5 successive waves of anthesis on the south slope at about 2400 ft. altitude, 1 in January and February, 1 in April and May, 1 in June, 1 in July, and 1 in August and September. The mean temperatures for these periods are approximately 5°C. apart, and the mean maximum and mean minimum of each period are also about 5°C. apart. Evidence is presented that anthesis is dependent upon temperature rather than upon moisture or hours of daylight, and that there are definite points of critical temperature for anthesis. The similarity of these facts to those previously recorded by the author for aquatic plants is noted.

59. This deals with 2 series of tests, made in 1919 and 1922, with seedlings of Pinus ponderosa, Pinus contorta, Picea Engelmanni, and Pseudotsuga texifolia, to determine the resistance of seedlings to high temperatures when the factor of drought is eliminated. In the 1922 tests, which were the more complete, the seedlings were tested 30 days, 46 days, 64 days and 92 days after sowing. The results indicated that under laboratory conditions which approached natural field conditions, the wilting of all species was mainly in the nature of a collapse of the stem at the ground line. For seedlings 30 days old, a temperature of approximately 141°F for 1 min. caused critical injury to all species. In all tests, Douglas fir seedlings were the most sensitive, especially at the low temperatures, while spruce came 2nd, at least at the higher temperatures. The order of heat tolerance (lodgepole pine, western yellow pine, spruce, and Douglas fir) closely approximates that assumed by Bates in studying the relation of transpiration rates to heat requirements. A free rate of transpiration offers greater protection from intense insolation than a more restricted rate. Extreme heat, though of short duration and rare occurrence, may be an important factor in preventing reproduction, and in limiting the natural habitats of the different species in the Central Rocky Mountains, where surface soil temperatures as high as 154°F have been recorded. Because of individual variations, it was not possible to determine absolute wilting temperatures or to define the relationship between time of exposure and the temperature.

60. The Plant as a Measure of the Habitat - Frederic E. Clements and Glenn W. Goldsmith publish many data in the Carnegie Institution Publication, No. 356, "The Phytometer Method in Ecology", on the growth and upon the performance of measurable functions, such as transpiration, by plants or small plant Communities, which they consider form the most trustworthy index to the habitat. They consider that the increasing standardisation of such "phytometer" methods will cause them to replace the less satisfactory of the instruments designed to measure individual factors of the environment, such as the atmometer, etc. This may be so, but the individual plant is such a complex recording instrument that the interpretation of its record of the habitat, even as a guide to the behaviour of other reasonably similar plants, is often a very difficult problem, and probably it will be long before the student of plant habitat ventures to plumb the possibilities of the environment without the aid of a battery of physical instruments, each designed to record the fluctuation in one separate physical factor, as rainfall, humidity, temperature, etc.

In

In "Nature" of 31st October, p.656, appears a note concerning the plant as a measure of the habitat, wherein reference to "The Phytometer Method in Ecology" by Clements and Goldsmith, is made.

The subject of the complexity of the individual plant as a recorder is correctly touched upon, and opinion is expressed that probably it will be long ere physical instruments can be dispensed with in plumbing the possibilities of the environment.

As workers in phytometry have been comparatively few, and are almost entirely American, it may be worth while to record very briefly indications as to the utility of the phytometer, obtained by me as the result of independent work.

South African native tree seedlings (e.g. those of Ocotea bullata, Olinia cymosa, Olea laurifolia, Platylophus trifoliatus, Cunonia capensis) are being tested as phytometers, the growth and transpiration responses under both natural and artificially produced habitats receiving initial attention. The results so far are distinctly favourable to the use of the plant as habitat measure; a short and preliminary account is to be published in the near future. For the forester, phytometric cultures, either free or under control, seem likely to prove valuable in returning information regarding the habitat as it impresses itself upon the plant, in throwing light on practices and processes either detrimental or conducive to the production of the optimum yield from particular localities, and in indicating the species best suited to the areas to be planted.

By many it is realised that the most elaborate measurement of the physical factors of the habitat by instrumental methods usually does not even approximately inform the investigator as to the nature of that habitat as it influences the living plant itself. The plant is the truest measure of the effects of the complex produced by the integration of the several habitat factors. Provided that points of such importance as the careful selection of suitable types of plants, the employment of large numbers of individuals so that abnormal ones can be eliminated, and the study of the several responses of the plant in conjunction with physical apparatus, receive careful attention in the first instance, it does not seem too optimistic to believe that, with increased knowledge of the behaviour of selected species, the phytometer by itself will give intelligible quantitative information as to the nature of the habitat.

The value of the phytometer for analyses of habitat and vegetation processes alike is likely to be as great as the study of this grand subject is alluring.

61. Phenological studies in Russia have a long history. After the first individual efforts to make and to publish phenological observations (1844-1888) they were established on a real scientific basis during the period from 1888 to 1923 by the late Prof. Kaigorodoff who organised them over all Russia by many correspondents whom he had recruited. After the Professor's death in 1923 his work was taken in hand by the Russian Society of Amateurs of the Study of the Universe, an entirely private society of amateur astronomers and meteorologists. This Society elected a special Phenological Committee, which undertook the organisation of a large network of phenological observation points and also the compilation, study and publication of the results. In the Spring of 1925 the number of Observers was 608 at 512 points. At nearly 75 points in European Russia phenological observations had been made for periods of 10 yr. to 20 yr. or more. Besides these points of observation there is a network of 58 points organised by the Meteorological Bureau of the Ukraine (South Russia).

The study of the large series of observations made at different points and during a long series of years permitted the Phenological Committee to draw up a table of the mean times of different natural phenomena at 17 typical centres distributed over all European U.S.S.R.

This table affords the possibility of comparing the natural phenomena of every spring and autumn with the mean times, and of deciding how far either event is too early or too late in the current year.

Such observations compared with results of the meteorological observations show generally a coincidence with weather conditions. A more precise idea of the gradual procession of the natural phenomena and of their dependence on meteorology can, however, be obtained also in another manner. Having a dense network of observation points, we can easily draw curves of isochronous events - isopipteses in the case of the arrival of birds, and isoanthes for the flowering of plants.

The Phenological Committee has tried to draw some curves for the spring of 1924, and also for the spring of 1925, and has obtained very interesting results.

The isoanthes in 1924 of the earlier plants as, for example, of the flowering of the wild bird cherry (Prunus padus) in the south and middle part of U.S.S.R. lie in a N.E. - S.W. direction, showing that in the east part the flowering began earlier than in the west part of the country, where it was retarded by some unfavourable conditions. But in the north part they lie quite regularly in a later period. The flowering of the lilac (Syringa vulgaria) shows nearly the same conditions.

The first cry of the cuckoo gives greater complications: the curves make a large tongue-like projection to the north, showing that the arrival of this bird was

retarded

retarded in the east as in the west, but that it succeeded in progressing on the nearly meridional line Poltava - Moscow - Kostroma - Vologda in the central part of U.S.S.R.

The explanation of this strange direction of curves is given by the study of the isobars of this spring. The isobars of 20th April are nearly parallel to the latitudes, as also are the isopiptoses of the cuckoo at this time. But on 23rd April a very strong cyclone burst in from the North-West and occupied the whole space between the Baltic and the Black Sea. The temperature fell and snowfall was recorded everywhere in this region so far as Jursk and Voronesh. The distribution of winds in this cyclone was such that in the middle part of Russia they were directed from south to north, and this is observed quite on the line Poltava - Moscow - Kostroma. West and east of this line the winds blow in the opposite direction. By these winds the cuckoo was driven northwards on the given line and retarded west and east of it.

On 5th May the isobars changed in such a way that in the north-east of Russia a strong anticyclone formed in the region of Volga and Kama. Therefore we see on the isopipteses of 10th May and 15th May that the cuckoo was rapidly progressing in this direction and was heard, 10th May north of Porm. New cyclones formed in the north-west part brought the cuckoo also to Novgorod and Pskov, and on 10th May it was heard not far from Leningrad.

These examples show us that by the existing large network of phenological observation points in the U.S.S.R. one can get results of great general interest.

62. *The conculsion is drawn that irradiation under certain conditions can cause a greatly increased retention of calcium and phosphorus by the pig and that such retention results from an increased absorption from the gut. Irradiation exerts its maximum effect when, as the result of a badly balanced diet or from other causes, the retention of minerals is low. When the retention is already good irradiation may have little influence.

The definite practical application of such results is shown by some earlier experiments; young pigs in dark pens put on less weight and at the end of the period were in a less thrifty condition than pigs which had been reared in pens in which the animals could obtain exposure to the direct rays of the sun. When the diet was deficient in mineral matter the beneficial effect of light was more striking. Unless a diet, ideal as regards its mineral content and mineral balance, is being fed, light will have a beneficial influence on the growing animal.

With

With goats the effect of light treatment was to raise the amount of calcium retained; this is of importance to a lactating animal with which there is normally a loss of mineral matter from the body during lactation.

It is certain that in our climate many animals suffer from the effects of too little sunlight. It is not so very long ago since a dark, badly ventilated and even dirty cowshed was thought to be good enough for a cow. There is a wide field for advance where the question of light, and particularly ultra-violet light is concerned. The fact that the latter from an artificial source or from a free natural source has such a profound effect on calcium and phosphorus metabolism and upon the general resistance of the organism to disease suggests unlimited applications in the rearing of stock as well as in human medicine.

63. The International Institute of Agricultural Ecology which was founded at Rome in 1923, with the object of co-ordinating and directing research on the growth and yield of crops all over the world, has now formed an International Commission of Agricultural Ecology. The British members of the Commission are Sir John Russell, Dr. B.A. Keen, Dr. C.A. Barber, Mr. W.S. Gray, and Prof. J. Percival. Some 30 countries are associated. The Executive Committee of this Commission has drawn up a programme of work under the three headings: (1) The principles of agricultural ecology (2) the ecological problem of wheat (3) the international network of stations of agricultural ecology. The programme is dealt with in detail under each of those headings.

The report divides agricultural meteorology into

(a) Meteorology applied to agriculture e.g. forecasting, the determination of the frequency of adverse meteorological phenomena, measures against hail, frost, etc.

(b) Agricultural ecology, i.e. the study of physical (especially atmospheric) conditions in relation to the growth and yield of crops.

The first if the business of the meteorologist, the second that of the ecologist who is studying the relations between climate and life can furnish data of value in practical agriculture.

Two international organisations are willing to assist the International Agricultural Institute in connection with its agricultural meteorological programme, viz:-

(a) The International Meteorological Committee of

London

London, composed of directors of meteorological services in the different countries. This Committee has formed a section for agricultural meteorology, presided over by Prof. Axel Wallén which would concern itself with meteorology applied to agriculture as defined in (a) above.

(b) The International Agricultural Ecological Institute founded at Rome which aims inter alia at securing an international network of agricultural ecological stations.

The report recommends that in view of the necessity of separating the two kinds of agricultural meteorology, of the economic importance of forecasting and statistics of crop condition, and of the need for agricultural ecological observations and experiments.

(1) The Permanent International Agricultural Meteorological Committee of the I.A.I. should be recommended to maintain regular and effective contact with the two international bodies (a) and (b) above.

(2) The International Meteorological Committee of London should be recommended to take charge of questions of forecasting and statistics of adverse meteorological phenomena.

(3) The International Agricultural Ecological Committee should be recommended to take charge of questions of the study and description of environment in relation to growth and yield of crops.

64. At the close of the year there were 121 stations, located in 40 different States, broadcasting weather forecasts and information by wireless on regular schedules. About 95 per cent of all the powerful wireless broadcasting stations in the United States are now co-operating and many of them broadcast forecasts for several States, and people in every section of the country are being served. The scope of the wireless weather service may be estimated when it is known that, for instance, in the State of Iowa alone there are over 33,500 receiving sets on farms. It is estimated that the weather forecasts are available by wireless to more than half a million farms in the United States.

An outstanding feature of the Weather Bureau's work last year was the warning given citrus growers the latter part of December of the approaching period of cold weather of unusual length and severity. On this information an additional 300 carloads and 175 truck loads of oil were rushed into the citrus districts to meet the impending emergency, which came as forecast. Eight specialists were assigned to duty during the frost-danger season in the citrus and deciduous fruit districts of the western States. There were urgent requests from fruit interests for additional service in other portions of the country. This service has become one of the most valuable conducted by the Bureau. Its co-operation with fruit growers materially assists in the saving of hundreds of thousands of dollars annually.

The fruit-spray forecast service is principally for the benefit of apple orchardists. In consists of special weather forecasts as a guide in the application of sprays to combat scab and fungous diseases. The season begins in early April

continues

continues into the latter part of June. The harvest weather forecasts are designed for the use of farmers during the harvesting season in determining when wheat, oats, and hay can be cut and harvested to the best advantage and with the least likelihood of damage from wet weather. The season runs from about the middle of June until the latter part of September. The fruit-spray service heretofore confined to the State of New York was extended in a limited way to other States, particularly Pennsylvania. The harvest-weather service was expanded to 44 counties in the State of New York. The past year was the first during which the projects were carried on as established programmes, owing to the availability of the specific appropriation made by Congress for the work. In one county alone the money value of the spray service to fruit growers was estimated from $40,000 to $60,000. It is estimated that about 24,000 farmers obtained the harvest-weather forecasts, and reports indicate that many thousands of dollars were saved by farmers who used the weather reports, and those who did not have reports in many cases lost heavily.

During the late summer and early autumn months fruit drying is one of the principal industries of the central valley of California. Fruit to the value of $40,000,000 to $50,000,000 is at times exposed to the weather in trays in the process of drying. The occurrence of rain without warning a sufficient time in advance to protect by stacking the trays or placing them under shelter would cause large losses from complete damage or deterioration in quality of the fruit. Therefore, much responsibility rests on the weather forecasters and the growers depend on the Weather Bureau to advise them when protective measures are necessary. In order that the best possible service may be given to this important industry arrangements were made during the year for providing the district forecaster at San Francisco and the local forecasters at Fresno and Sacramento with special observations by telegraph from points in California and near-by States whenever conditions indicate the probability of rain in the raisin-growing districts.

The great flood period of the year was that of January, 1925, in the rivers of the South Atlantic States. The warnings of the coming, duration and extent of the floods were issued with timeliness and accuracy. Special efforts of the Weather Bureau in assembling data and issuing flood warnings during the flood crisis were estimated to have been the means of saving $1,000,000 to the citizens in river territories in middle and southern Alabama. Much property was saved during the year in other portions of the country through the flood warnings of the Weather Bureau, the total reported value of property saved being $2,209,975, which, of course, is not a complete record of the saving effected.

65. The present work is best described as a text-book of physiological plant ecology and originated from a series of lectures given in the winter of 1923-1924 at the Masaryk University of Brno (Brunn). The preface is dated June, 1925, from the south Swedish ecological station of Hollands Vadero. The basic thesis underlying the subject-matter chosen and its arrangement is that only by understanding the physiological actions of the various factors influencing plant life can their ecological value be correctly estimated. However, in each main

subdivision

subdivision laboratory methods and results are closely linked to field studies, and it is shown how causal explanations often depend on physiological experiments. The main chapter headings of this useful book indicate its scope, and are as follows:- The light factor: The temperature factor: The water factor. The soil, its formation and general ecological peculiarities. The physical nature and aeration of the soil. The chemical soil factors. The micro-organisms of the soil. The carbon dioxide factor. The guiding principles of experimental ecological research. The last chapter is of special interest and importance to all interested in the modern problems of phytogeography. Mention must be made of the numerous references to literature. The author has made a generally successful attempt to bring together the latest facts in each subject with which he deals, and it is pleasing to note that due importance is frequently attached to the researches of British ecologists. The paragraph on mycorhiza is the least satisfactory portion. The work is accompanied by a summary of contents, 113 text-figures (mostly diagrams and graphs), two folded maps and separate indexes to authors, subjects, and plant names.

66. In an elaborate study of the effects of high temperatures on seed corn, it was found that air-dry corn (containing from 10 per cent to 11 per cent. of moisture) was killed by exposure to 80°C. for 25 min. and to 90°C. for 10 min. and injured by exposure to 70°C., 80°C., and 90°C. for 80 min., 10 min. and 5 min., respectively. Resistance to heat varied inversely as water content. Air-dry diseased corn contained the most moisture, disease-free corn, the least, and badly diseased an intermediate amount. After desiccation over sulphuric acid diseased corn contained the least moisture, disease-free corn the most, and badly diseased an intermediate percentage. After desiccation diseased corn was much more resistant to heat, as compared with disease-free or badly diseased corn, than its slightly less moisture percentage would indicate, this greater resistance becoming evident, however, only as the temperatures become injurious. The nature of these changes is not apparent.

Desiccation over sulphuric acid is said to be greatest at points farthest removed from the acid, and to be least at points closest to its surface. This gradient gradually decreases as the period of desiccation lengthens.

Resistance of air-dry corn to heat, both in the laboratory and in air out of doors, is a function of humidity, the three kinds of corn tested varying similarly. Viability is not affected by placing the corn in water immediately after it is heated. Rag-doll tested corn germinated better than did soil-germinated seed. General correspondence is shown between germination percentage and growth of seedlings in the case of both treated and untreated seed.

Germination percentages, green weight, and height of plants of heated corn grown in soil parallel the behaviour

shown

shown in germination in rag dolls. In air-dry corn the disease-free is consistently highest, diseased lowest, and badly diseased intermediate. In desiccated corn the diseased is consistently highest, disease-free usually lowest, and badly diseased variable between lowest and intermediate.

67. * Experiments with Locusta Migratoria show that temperature conditions during breeding have a great influence on the normal development and general health of this insect. There is a certain limit of favourable temperature, below which the development of the genital products in the imagines ceases, and the insects easily succumb to bacterial diseases.

The experiments were carried out in wooden cages with glass walls warmed by electric lamps, the necessary moisture being produced by water evaporation. In the first experiment when the temperature was maintained at 95°F.-100°F. and the humidity nearly at saturation point the development of the insects was very rapid. In the second experiment the larvae when in the 3rd instar were transferred into a lower temperature, which fluctuated between about 86°F. by day and 68°F. during the night. The humidity was about 70 per cent. The larvae under these conditions developed slowly. They became sluggish and ate little. Some died during their moults; others transformed into imagines after remaining in the alternating temperature for 46 days: The duration of development was 30 days longer than in the first experiment. But most remarkable was the influence of low temperature upon the maturation of the imagines, which could not mature and died without laying their eggs. This effect was observed not only in the locusts bred in artificial conditions but also in individuals collected from their natural environment.

Compared with the results of the experiments, the development of the locusts in nature after the period of flying was in the same stage as that reached by the locusts that had been reared at a high temperature for a month: the increased oxidation consequent on the physiological action of the efforts of the insects in flying resulting in a rise of temperature.

The results of another experiment confirmed the opinion that Coccobacillus acridiorum is a normal symbiont in the blood of locusts, but that this symbiont can become a dangerous parasite under unfavourable conditions of temperature and humidity.

68. * Under approximately normal conditions and at constant temperatures, seed pieces from potatoes of only moderate resistance are infected by Fusarium oxysporum at approximately 14°C., but not at lower temperatures.

From

69. From the data presented, it is evident that Ophiobolus graminis is a vigorous root and tiller-base parasite, and also that infection is greatly influenced by soil temperature, and soil moisture. Although the temperature and moisture optima shifted slightly in the several experiments, it is evident that infection and injury are favoured by moderately low temperatures (54°F. to 61°F.) and by fairly high soil moistures (70 per cent. to 80 per cent.). In these studies it was found that O.graminis causes practically no injury to the very young seedlings just before emergence. The germination of seeds planted in the inoculated soils was not consistently lower than that of seeds sown in the uninoculated soil; in fact it was not uncommon to find that the germination of seed in the control soil was actually lower than that of seeds sown in the inoculated soil. It was found in these studies that infection seldom took place until the seedlings were well advanced. This was found to be the case even in the experiments in which the greatest quantities of inoculum were used. When small quantities of inoculum were used the plants showed little infection until they were well advanced.

An examination of the summary curves shows that the optimum temperature for tiller-base and root injury was 54°F. in soil containing the medium amount of water, whereas 61°F. was the optimum temperature for these injuries in soils containing low and high soil moistures. Whether this shift represents an actual relationship between the joint influences of temperature and moisture or merely experimental variation is a question. The data given for the individual experiments show that the temperature optima shifted from time to time, regardless of the moisture content of the soil. This indicates that some other factors which were not so well controlled as soil temperature and soil moisture may have a decided influence on the occurrence of the disease and that the temperature optimum probably extends over a range of at least 70°F. to 11°F. The quantity of Ophiobolus inoculum placed in the soil has a marked influence on the behaviour of the take-all disease. However, it is much more difficult to standardize the amount of inoculum of O.graminis than is the case with the inoculum of other parasites and as the strains of O.graminis employed in these studies differed in their virulence it was frequently found that the quantity of inoculum used was in excess of that which would give the sharpest indications of the temperature and moisture optima.

70. The first part of these notes deals with the theoretical calculation of the probable height of capillary rise, dependent upon the diameter of the tubular passages and consequently of the soil pore spaces. Part II deals with the experimental determination of capillary rise in different soils, those used being sand, silt and siliceous clay. In sand water rises very quickly but only to the small height of 55 cm. after 3 days and remains at that height. In the silts of the high plains of the province of Beauce the absorption is slower at the beginning but continues for a week and reaches a height of nearly 80 cm. In the sample of silt from Lomas de Zomara near Buenos Ayres and in siliceous clay the capillary rise is considerably slower as the water takes 191 days to attain the height of 1 m.

71. This report results from a plantation of Pinus strobus and P. resinosa established in 1920 near Syracuse, New York. The latter proved the more resistant to wind desiccation. Repeated winter killing of foliage by winds may kill young trees on exposed

sites

sites and exclude trees from shallow soils. Growth and yield are affected by wind, hence it should be considered in selecting a site for planting.

72. * In earlier investigations it was seen that when two co-ordinate branches of an individual plant of Cosmos bipinnatus are exposed to light for daily periods of different length each branch responds in characteristic manner to its particular light period more or less independently of the other branch. Continuing the investigations, experiments have been made with Cosmos sulphureus, a typical short-day plant, in which different portions of the primary stem were exposed to different daily periods of illumination, and, in some instances, to continuous darkness.

When the upper portion of the plant was exposed to the full length of day or summer while the lower portion received only 10 hr. of light daily, the latter promptly flowered while the former remained vegetative. These localised responses might, it is supposed, continue for several months under favourable conditions.

Thus each portion of the axis has responded to its particular light period,, in much the same manner as if it had been a separate plant.

Definite localisation of the response was likewise obtained when the upper portion was subjected to a short daily period of illumination, and when the lower was exposed to a long one, and the former flowered readily while the latter continued to develop vegetatively.

When the central portion of the axis was exposed to a long day while both the lower and uppermost portions were subjected to the action of a short day, flowering was initiated in both the latter portions of the axis while the central portion continued to develop only vegetative shoots, further illustrating the possibility of sharply localising the response to length of day.

On the other hand, when the central portion of the axis was exposed to a short day and the upper and lower portions to a long day, flower buds appeared in the former while both of the latter remained vegetative.

When the upper portion of the stem was excluded from light continuously for a period of 3 weeks to 5 weeks while the lower portion received the light of a short day and consequently was forced into flowering, formation of flower buds was induced in the upper, darkened portion, and open blossoms appeared after the top had been returned to the full length of day. When, however, the lower portion of the axis received the light of the long summer day and therefore was prevented from flowering, while the upper portion was maintained in continuous darkness, the latter formed no flower buds and resumed vegetative activity when returned to the light.

hen the entire plant was excluded from the light for a period of 10 days and then r turned to the action of the long day, flower buds did not appear.

These tests seem to indicate that, under the conditions, continuous darkness in itself does not definitely initiate flowering, but that, on the other hand, it does not necessarily inhibit formation of flower buds in response to the action of a short daily light period on another part of the plant.

The

73. The experiment was made on barley and peas to test whether their growth may be appreciably promoted by the action of electric light, without increasing the quantity of CO_2. Plants were illuminated during the night by an electric light of 100 c.p. It was found that (1) the growth is much quicker in the night-illuminated than in the control plants, (2) the development of inflorescences takes place much earlier and (3) the length and weight of different parts are much greater.

74. These results suggest that the polarised light favours bacterial life as compared with ordinary light of equal intensity.

75. Drs. Colwell, Gladstone, and Wakeley, give an account of a series of experiments designed to test the effect of X-rays on the developing embryos of the fowl. In an earlier paper the authors concluded that, in embryos irradiated immediately before incubation and then daily for several days, the action was always inhibitory the irradiated embryos being invariably smaller than the controls. Those which received the full pastille dose of X-rays were most affected, 6 out of 9 showing no development at all. In all those showing development, all tissues and organs which should normally be developed were differentiated but smaller in size. The effect was therefore one of retardation or diminution of growth. In the present paper the authors give the results of experiments in which the embryos were allowed to develop normally for 4 days and then subjected in 2 groups to daily irradiation of 3 days and 5 days respectively. In these cases there did not seem to be any marked effect on the average length of the embryos compared with controls. The principal action of the rays appeared to be their destructive effect on the tissues and on the red blood corpuscles.

76. The most important relation in plant ecology is the reciprocal one existing between the plant itself and its environment. Any attempt to determine exactly the causes which produce modifications in individuals and, consequently, in general growth, must include measurement of all the environmental factors. This must be done by means of instruments of precision. In this way however, isolated data difficult to interpret are obtained, whereas it is necessary to have an integral idea of environment, which can be given only by the living organism, i.e. the plant. The object of the author's work is to analyse the intricate relations between plant and environment, so as to determine more exactly the effect of varying amounts of factors upon plant response.

The most important factors on which yield is dependent are the relations between water on the one hand and soil and air on the other; the other factors are only accessory. The yield of pure stands of short grasses, wheat-grasses, mixed short and tall grasses, and mixed tall grasses, was found to decrease from the true prairie through

mixed

mixed prairie to short grass plains in direct relation with the available water and nutrient matter content of the soil and, inversely with atmospheric evaporation. The same relation was determined for oats, wheat and barley, and also for alfalfa, sweet clover and maize. In general it may be concluded that the wild and cultivated plants integrate the conditions of environment and through yield, express them quantitatively.

77. * An analysis of the effect of 7 environmental factors on the growth of barley in pot culture has been undertaken.

The environmental factors are:

1. Maximum day temperature.
2. Average day temperature.
3. Minimum night temperature.
4. Average night temperature.
5. Total radiation in calories per sq.cm. per week.
6. Hours of bright sunshine.
7. Evaporating power of the air.

Three measures of growth are dealt with:

1. Net assimilation rate (dry weight increase per unit leaf-area per unit time).

2. Relative rate of growth of leaf surface.

3. Relative rate of increase in dry weight (efficiency index).

The whole growth cycle is divided into two parts at the point at which maximum leaf-area occurred, and each half is considered separately.

Net assimilation rate. During the first part of the growth cycle the net assimilation rate is shown to be independent of time and of the quantity of nitrogen added as manure. The partial correlations of assimilation rate with day temperature and radiation are significantly positive and high in value, while a significant negative correlation with night temperature obtains. The values of net assimilation rates calculated from the regression equation are graphically presented together with the experimental values, and good agreement is found. Over 80 per cent. of the variation in assimilation rate is accounted for by variation in external factors.

Relative leaf-growth rate and efficiency index. The method used for the study of the variations in these processes due to environmental changes consists essentially in determining the approximate form of normal curves for the two cases, such that varying rates are conditioned solely by internal factors, while the external factors may be supposed to remain constant at their mean values.

The differences in the slopes of comparable portions of the experimental and normal curves are taken to represent the effects of the external factors, an increase

in

in slope indicating acceleration, and a decrease inhibition. Partial correlations of relative leaf-growth rate and average day temperature are significantly positive, and a significantly negative correlation with night temperature is again found. A large significant negative correlation with total radiation appears, while relative leaf growth is found to be almost independent of net assimilation rate. A spurious correlation between net assimilation and relative leaf growth is due to both processes being highly positively correlated with average day temperature and negatively with average night temperature.

Efficiency index. In the first part of the growth cycle, the efficiency index is almost independent of radiation, but is highly positively correlated with average day temperature and significantly negatively with night temperature. In the second part of the growth cycle all the correlations decrease in magnitude with the onset of ripening.

The physiological adaptation of the barley plant to climatic changes is brought out clearly by the partial correlations. The antagonistic effects of the correlations with total radiation - positive in the case of net assimilation, negative in the case of relative leaf-growth rate - tend to maintain the yield constant. In the absence of bright sunshine, in so far as the temperature does not fall, the high relative leaf-growth rate will lead to a large leaf surface and hence compensate for the low net assimilation rate, and vice versa. This compensating effect, however, is partially masked by the high nitrification rate in the soil associated with high soil temperature and hence with total radiation. High nitrogen content in the soil will tend to increase leaf-growth irrespective of the inhibiting effect of bright sunshine.

78. *Of the water retained by the soil, a portion remains adhering to the soil particles as a thin layer held by absorption, while the rest collects in small hollows and crevices, where it is retained by capillarity. hile the retaining power of the capillarity is only slight the absorbed water is held back with rather considerable force.

Sachs found in 1859 that the water-retaining power of quartz sand was rather feeble as compared with that of clay soil or of sand mixed with humus.

A simple determination of the water content of the soil, therefore, does not furnish any basis for a true estimation of the amount of water actually at the disposal of the plants. To determine this, it will be necessary to determine the water-retaining power of the different soils with various contained water percentages.

The method used in this paper consists in determining the strength of the sugar solution which has the same vapour pressure as the soil sample under investigation.

The results of the experiments show that the water-retaining power of pure quartz sand is extremely slight. A comparison of the curve for pure quartz sand with the one for sand mixed with clay shows that the clay

content

content plays a great role as regards the water-retaining power, the latter rising, owing to the presence of the clay, to as much as 13 atmospheres or 14 atmospheres when the soil contains 5.5 per cent of water. With a lesser content of water the retaining power of the sand and clay mixture rises somewhat less rapidly than in the pure sand.

The garden soil which forms the subject of the 3rd experiment differs from the sand and clay mixture chiefly by its content of humus, and it is noticed that this admixture tends to increase the water-retaining power, which here, for a water content of 8 per cent. reaches between 13 atmospheres and 14 atmospheres.

It is in pure clay and pure humus that the water-holding power is greatest. In beech mould it is as high as 13 atmospheres or 14 atmospheres with a water content of 23 per cent. or 24 per cent. As a curious feature it should be noted that with decreasing water content, the increase in water-retaining power is much slower here than in the first three experiments.

79. Our appeal in Nature of 25th October 1924, and 25th April 1925, for international phenological co-operation has met with unexpected response. We now know that, on the continent of Europe alone, apart from individual workers, networks of observing stations have been established in the following countries.- Holland, under Dr. H. Bos: Belgium, under the late Prof. Vanderlinden; Norway, under Ascho Hoe; Germany and Austria, under Dr. E. Ihne; Czecho-Slovakia, under Prof. J. Kopecky; Hungary, under Dr. J. Schenk: Tyrol, under Dr. W. Pfaff: North Italy, under Dr. M. A. Minio: Russia in Europe, under Prof. P. Schmidt. Of these, we had previously been in touch with Holland, Belgium, and Germany only.

The total number of stations exceeds 2,000 besides more than 350 in the British Isles. Dr. A. D. Hopkins carries on similar and more organised work in the United States, and it is developing in Western Canada. Numerous isolated observers in Europe and in the more distant British Dominions, Java, etc., are in touch with us. Agricultural colleges are participating more and more as they realise the practical value of phenology.

* * *

We wish to make it clear that there is at present no central body to collect and, above all, tabulate results. This must be done by each country independently, after having circulated to their observers such a list, selected from the suggested International Schedule, as best adapts itself to local conditions, including the same as part of or as supplement to, their present schedule. All the lists sent us already include quite a large number.

In the course, say of 10 years, we may well hope that these records will be collocated and produce, directly and by correlation, interesting data for scientific analysis and also of value for agricultural and other practical applications.

80. Interrelationships,

80. Interrelationships, if they exist at all, between solar activity and terrestrial phenomena can best be demonstrated and their intensity measured by the determination of the correlation between some measure of the sun's activity. and terrestrial variables.

The only measure of solar activity available for a protracted period of time is that of the sun-spot relative numbers. The most usable measures of terrestrial phenomena which might possibly be influenced by solar variation are the instrumentally determined values of meteorological phenomena and the record of the rate of plant growth as embodied in the trunks of trees.

Co-efficients of correlation and the antecedent means and standard deviations were computed from the original sun-spot numbers of olfer and the tree-ring diameter measurements of Douglass without grouping of either of the variables.

The co-efficients, taken as a whole, indicate a low positive correlation between sun-spot number and tree-growth. The relationship is by no means so intimate as many writers imply.

81. In a lecture delivered before the Royal Geographical Society on 15th February, Dr. E. J. Salisbury discussed very fully the relation between the geographical distribution of plants and climatic factors. Although the effect of the various climatic factors upon plant growth is primarily one for investigation by the physiologist, yet the application of the results of these investigations must continue to remain the province of the ecologist or plant geographer, whose particular outlook must be much more influenced by the conception of competition as a factor of vital importance. Climate may delimit 3 zones in the distribution of a given plant, viz 1. a zone in which both abundant vegetative growth and reproduction are possible: 2. a zone, in which normal vegetative growth ensues but reproduction is possible only in exceptional seasons: 3. a zone, in which the plant may be cultivated but will not reproduce. To be of real use, plant distribution maps should, therefore, also indicate the relative abundance in different areas of the species under consideration. Dr. Salisbury also pleads for detailed maps showing the actual rainfall not corrected to mean sea-level, and for maps showing the seasonal distribution of rainfall.

82. Agricultural meteorology, plant breeding and other allied sciences have been studied by many investigators, but a correlation of these studies is now required.

Agricultural ecology attempts to determine by the study of specific differences in growth and other characters, what varieties of cereals, etc., are suitable for cultivation under any given climatic or environmental conditions.

The limiting factors of a crop may be physical,

chemical

chemical or biological, and the investigations of the meteorologist, chemist and geniticist may often form different phases of a larger problem, hence the importance of co-operation, and also of a central directive body to act as a clearing-house for information.

The importance of breeding rust-resistant varieties of wheat is evident, but because a wheat is resistant it does not follow that such will be the case under other conditions. In the description of such a variety should be recorded the climatic and other conditions for which these qualities hold.

The problem requires the collection of data respecting rainfall, soil humidity, temperature, etc., also data relative to particular crops, for instance, times of sowing and harvesting; such knowledge is essential to the plant breeder to enable him to obtain or to select the type most likely to succeed in a given environment.

The critical periods of a crop have special significance. By the term critical period is understood the interval during which the plant reaches the maximum sensibility to a given factor, and during which variations in the intensity of that factor will have the greatest effect on yield. The 20 days before heading constitute a critical period for wheat, in relation of humidity. If during that period the rainfall is less than the minimum needed for the normal development of the plant, the crop will be small, even if there is abundance of rain later on. The critical periods always coincide with certain phases of growth, during which certain climatic conditions are essential if development is to proceed at a maximum rate.

The influence, both of the time of application and the quantity of water has been shown by the experiments of Prof. Azzi at the Botanic Gardens of the University of Rome, on four varieties of wheat. Koënig has shown the existence of critical periods in the case of sugar cane, from data collected over a series of years from 27 stations in Mauritius.

It is not the absolute value of a meteorological factor that counts, but its distribution during the different stages of the growth-period of the plant.

The yield of a crop is the result of a compromise between productivity and the degree of resistance to adverse environmental factors. At Svalof, a hybrid wheat, Pansar, yielded 67 per cent. more than the local wheat; this hybrid was grown at other stations farther north, and a point was reached where the temperature factor became important and the local type yielded more than Pansar, owing to the greater cold-resistance of the former.

Briefly, the aim of agricultural ecology is the determination of the climatic zones of wheat and other plants throughout the world, and the co-ordination and direction of research, the ultimate object being the possibility of stating definitely what crop, and what particular variety of the crop, is most suitable for any given climatic and environmental condition.

To Prof. Pirotta of the Accademia R. Dei. Lincei, Rome, and to Prof. Azzi is due the foundation at the R. Accademia, of the International Institute of Agricultural Ecology which has been recently established.

83. This bulletin describes investigations into the generation of electricity by wind-power, initiated by the Research Branch of the Ministry of Agriculture, and transferred to the Agricultural Engineering Institute on the establishment of the latter.

Seven windmill generating plants were under trial at the Testing Station at Harpenden. The cost per unit of electricity (including depreciation on plant and battery) was found to vary from 4.0d. in the case of the Agricco Mill to 12.7d. in the case of the smaller Garty Apex Mill. (a later type of Garty Apex gives results as good as 6.4d. per unit).

The wind data may be referred to in detail as of interest to agricultural meteorologists. Two classes of observations were taken:-

(a) General records of daily wind conditions, speed and direction, taken over a whole year June, 1924, to May, 1925.

(b) Direct accurate readings of wind speed at any desired moment to be related to the output of any mill at that moment.

Observations under (a) were made on the standard Dines Pressure Tube Anemometer. Observations under (b) were made on the portable Diaphram Anemometer. In addition the equipment included a Peandar Electric Recording Anemometer. The testing field sloped south-west. It was 17 acres in area, of which 12 were occupied by the mills. The centre of the head of the mills varied from a height of 10 ft. 6 in. to 60 ft., and the head of the portable anemometer was mounted as near as possible to the wind-wheel, to ensure that the recorded speeds represented the conditions at the wheel. Useful wind speeds were taken as those above cutting-in speed (approximately 8 m.p.h.). To obtain a simple factor which would express for one day the wind conditions in so far as they affected the output of any windmill generator, each daily Dines chart was divided into speed ranges of 8 m.p.h. to 10 m.p.h., 10 m.p.h. to 15 m.p.h., 15 m.p.h. to 20 m.p.h., 20m.p.h. to 25 m.p.h., etc. and the number of hours of wind in each range was tabulated. Each of these time readings in each range was multiplied by the average speed of the range, i.e. 9 m.p.h., 12.5 m.p.h., 17.5 m.p.h., 22.5 m.p.h., etc. Thus for each speed range was obtained the miles of wind, and by adding up all the ranges the total miles of wind for the day were obtained. The term mile-hours as applied to this includes all miles of wind per day. This treatment was applied to the daily Dines Charts for a complete year, and tables were drawn up of the mile-hours for every day throughout the year. A table gives for each month the hours of wind at different speeds at a height of 60 ft. above the ground, all speeds above 30 m.p.h. being identical for generating purposes owing to the action of a governor which causes the wheel to turn out of the wind.

84. Referring to Scharfetter's article on the response of plants to the climatic rhythm, it is pointed out that, as is to be expected, native plants utilize the rhythm better than introduced plants.

I. Scarlet Pimpernel (Anagallis arvensis).

This flower has not been observed open at night. The diurnal duration of the flower's expansion is restricted to 8 hr. to 9 hr. even in the long mid-summer days.

The records clearly point to relative humidity as a controlling factor in the irregular movements during the day. The critical value is approximately 80 per cent., i.e. when the humidity was above this value the flower was never recorded fully open.

II. Common Daisy (Bellis perennis).

No exceptions to its nocturnal sleep have been noted. No correlation between flower movement and light intensity or cloudiness is apparent from either observations or experiments.

Relative humidity is a controlling factor, the movement occurring between 64 per cent. and 82 per cent. of saturation.

Soil temperature exercises some influence, but whether this be secondary in so far as it affects the relative humidity is uncertain. The approximate critical value is 52°F., and for surface readings 58°F.

III. Common Chickweed (Stellaria media).

The temperature of the soil surrounding the roots and that of the air surrounding the plant are controlling factors in the flower movement. The critical value for the former is 50°F., that of the latter 1°F. higher. Above these temperatures, relative humidity becomes the dominant factor of control during the day, the closing movement taking place between 71 per cent. and 82 per cent. as recorded in the screen.

IV. White or Dutch Clover (Trifolium repens).

Apart from the regular diurnal movements, it is the wind velocity that is the cause of the movement during the day. When a velocity below 20 m.p.h. in gusts is recorded at the height of a Dines pressure tube anemometer (42 ft.) the leaves are always found open. Above 20 m.p.h. as the velocity increases the leaves gradually approach until when gale force is reached they are completely shut.

V. Dandelion (Taraxacum officinale).

An examination of the surface temperature reveals a critical period between 46°F. and 51°F. - the flower was always recorded shut below the lower value and always open above the higher.

Conclusions.

Not one of the plants investigated above has justified its reputation to predict with certainty local weather changes. The irregular movements during the day are due to changes in the various meteorological elements, and at best are but synchronous with the latter whilst in many cases there is definite lag.

Temperature at the surface of the soil appears to be a controlling factor in the movements of daisy, chickweed and dandelion, although not well defined. The daisy and chickweed respond more precisely to the temperature of the soil about their roots.

Above the critical temperature, the daisy and

chickweed

chickweed definitely respond to change in relative humidity, 82 per cent. being the critical maximum in each case. The scarlet pimpernel like ise appears definitely sensitive to a value of 80 per cent. The values are approximate as the hygrometric readings are those for the air 4 ft. above the plants. The approximate common value for three plants, distinct in many respects, is remarkable. Whether this element operates by controlling the rate of evaporation from the surfaces of the bracts or by some other means, must be left for the plant physiologist to determine.

Daisy, chickweed and pimpernel would therefore justify their reputations to forecast rain to the extent of the number of hours that elapse between the prerequisite humidity increase and the incidence of precipitation (assuming the air temperature to be above the critical minimum). Unfortunately, there are many exceptions to this sequence of changes, whilst humidity frequently increases to saturation without rain as an immediate sequel.

Wind-velocity as the control factor in the irregular leaf movements of clover during the day may be merely a mechanical effect, the leaves being forced into positions offering the least resistance to the air movement.

The results indicate that the uncertain response of the plants to the incidence of precipitation can be explained by coincident humidity or temperature changes.

The diurnal movements morning and evening are best described as regular habits, and do not appear to be subject to the weather conditions of the moment in the same degree as do the erratic movements under investigation.

86. * It is suggested that the phenomena of response to relative day-length may be materially influenced by the particular temperature and humidity conditions to which the plant may be subjected during its growth-period. In this experiment certain plants known to react to relative day-length were subjected to two sets of temperature and humidity conditions. Marked results were obtained in the modification of the length of the vegetative activity.

Dependent upon the species, one or the other set of conditions proved best for the modification of the response to relative day lengths.

87. * The injuries to apple fruit resulting from certain periods of high temperature have been described and attention called to the fact that the effect of a particular temperature has varied with the conditions under which the fruit was growing

The losses from heat have occurred when extremely high temperatures have been preceded by periods of relatively cool weather.

A shortage of soil moisture has apparently been a factor in the development of heat injury in many of the cases reported.

Starved or stunted apples have shown a greater

resistance

resistance to heat injury than those that were making a normal or rapid growth.

The location and the pattern of heat injuries have apparently often been determined by the extent of the previous exposure, fruit surfaces that have been previously exposed to strong sunlight being more resistant than those that have been partially protected.

The exposed sides of exposed apples may have temperatures 10°F. to 16°F. higher than the shaded sides of the same apples and 12°F. to 25°F. higher than the air in the shade.

The exposed sides of exposed apples have a uniformly higher sap concentration than the shaded sides of the same apples.

88. Preliminary experiments in which tomatoes inoculated with the crown-gall organism were kept at 18°C. to 22°C., 29°C., to 30°C. and 36°C., to 38°C. showed development of gall only at the lower temperature range. Also inoculated stems of raspberry and tomato which were kept saturated with moisture showed increased development on galls, compared with others exposed to the air. This was especially true of the raspberry.

Tomato stems were inoculated by needle punctures with the crown-gall organism, and the inoculated parts were placed under soil which was held for different plants at 14°C., 18°C., 22°C., 26°C., 30°C. and 34°C., respectively. At each temperature soil moisture trials were also made at 20 per cent., 40 per cent., 60 per cent. and 80 per cent. of the moisture-holding capacity of the soil. The greatest development of the aboveground parts of the host was reached at 22°C. to 30°C. and 80 per cent. moisture. The largest galls were found at 22°C. for all moistures and at 60 per cent. moisture for all temperatures. Gall development was reduced at 30°C. and above. The optimum of both temperature and moisture for disease development on the tomato was found to be slightly lower than that for the host plant.

A temperature tank series in which raspberries were employed gave inconclusive results in regard to gall development, but suggested a range similar to that of tomatoes.

The critical temperatures of gall formation were further tested in chambers where the air temperatures were closely regulated. At 28°C. to 30°C. only poorly developed galls were obtained, while none at all developed above 30°C. The tomato plants, however, grew fairly well above 30°C.

Inoculated tomato plants kept in chambers where the air temperature was regulated to 8°C. to 10°C. made practically no growth and produced no galls during a period of one month.

The temperature relations of the crown-gall organism were studied with three kinds of media. On nutrient-dextrose agar the largest colonies were produced in the range of 14°C. to 30°C. In modified Colley's medium the largest vegetative activities as well as acid production occurred over the same range. In tomato decoction the greatest pH change, which was on the alkaline side, covered the same temperatures. These all correlate closely with the production of galls in tomato.

Previous

Previous infection did not appear to influence gall development. Tests for precipitins and agglutinins in the host tissue near the galls and in the galls proper gave negative results.

The crown-gall organism did produce agglutinins when injected into a rabbit. The serum was effective in dilution of 1 in 3,000

89. * Whenever the temperature and precipitation curves are ascending the rounding curves, as they are for localities like the Gulf Coast States, China, and even South Africa, conditions essential for the development of canker are at hand, as these same conditions stimulate the rapid growth of the host plants, and thus make them more susceptible. On the other hand, no canker has ever been found in those localities, where, while the temperature curves are ascending and rounding ones, the precipitation curves are descending. In California, when the highest monthly mean temperatures are reached, the amount of precipitation is at its lowest point. If most of the annual rainfall occurred, during the summer months rather than during the winter season, canker could develop to some extent, as conditions would then be similar to those prevailing in South Africa and at Laredo, Tex., in 1916. The amount, frequency, and seasonal distribution of precipitation is a limiting factor in the development of both diseases in question. Apparently the seasonal distribution is the most important factor to consider, for on the seasonal distribution of rainfall depends, to a large extent, the development or inhibition of these diseases in the citrus regions of the world.

90. * The soil environment, and especially the soil temperature during the short period following germination when the onion seedling is susceptible to infection by the smut fungus Urocystis cepulae Frost, has an important bearing on the amount of disease which results. Previous studies have shown that abundant infection occurs at a temperature as low as 10°C. to 12°C., which is nearly as low as that at which germination and growth of onion ordinarily occurs. There appears thus to be no low point at which the host escapes the disease. Infection occurs equally well up to 25°C., but above that a rapid reduction occurs, while at 29°C., or above the onion seedling will grow free from the disease.

The purpose of the present study has been to determine whether this temperature inhibition is the result of direct effect of temperature upon the parasite, of host response to temperature, or the combined effect of both.

By studying the germination and growth of the fungus on artificial media the effect of temperature on the parasite under these conditions was determined. It was found that the minimum temperature for germination and growth of U. cepulae was very close to that of the onion plant. The optima for chlamydospore germination, hyphal-fragrant, germination and vegetative growth of the thallus lie between 13°C. and 22°C. Above 25°C. there is a decided reduction in the amount of germination which occurs, and the growth of the hyphae becomes more meagre as the temperature rises. Such

hyphae

hyphae as do appear above 28°C. not only grow very slowly, but soon lose their viability upon continued exposure to these higher temperatures. On the contrary, protracted exposure to near-minimum temperatures does not so affect the slowly growing thallus.

There is no appreciable change in the rate of growth of the host or in the length of its susceptibility when grown slightly above or below the critical point (29°C.) above which no infection occurs. Further study is needed to determine whether there are changes in the host tissue at the high temperatures which render it immune to infection. The marked inhibitive effects of temperatures above 25°C. upon the parasite, with the maximum lying only slightly above 29°C., show the direct influence of temperature upon the parasite to be a primary factor in the limitation of infection.

Although the smut organism is being continually introduced throughout the country on northern-grown onion sets, the disease has as yet never been recorded in the intensive southern onion growing regions, while it has become established in most of the intensive northern sections. Likewise, in Europe the disease is largely confined to the northern, cooler areas. The results of this study strengthen the theory advanced earlier that temperature is one of the important factors which bring about this regional limitation of the disease.

91. The seed coat is little affected directly by climatic conditions, but high temperatures and low humidity at harvest time result in excessive and rapid drying, which favours cracking of the coat and consequent injury from seed-treating solutions. In barley and oats the percentage of glume is relatively higher when grown in hot, dry localities, than in cool, moist ones. Freshly harvested seed does not have full germination maturity. The degree of such maturity is largely determined by climatic conditions. Furthermore, full germination capacity is attained more quickly in winter than in spring sorts. Seed at the milk and yellow-ripe stages requires relatively lower temperatures for germination than fully matured seed, but "green-ripe" seed, in contrast, germinates better at higher temperatures. Hot, dry weather preceding harvest, results in substantially better matured seed than cool, humid weather. Temperature and humidity conditions determine the moisture and protein content of wheat at harvest. In breeding wheat for a combination of high yield and high protein content, for cool, moist regions, comparative determinations should be made (1) of the absolute nitrogen-formation capacity of different wheat sorts, and those selected which have the highest capacity; and (2) of the conditions under which nitrogenous substances are transformed into protein, and those selected which have the highest capacity in this respect under unfavourable climatic conditions. In order to make progress, plant breeding must be founded more fully than heretofore on knowledge of the physiological processes, such as those obtaining in the relationship between climate and the quality and condition

attained

attained by grain at the time of harvest.

92. In connection with a general discussion of the correlation between meteorological conditions and the incidence of plant diseases, the phenological data on apple scab (Fusicladium) (Venturia inaequalis) presented in an earlier paper are recapitulated. Suggestions are made for various developments in the present method of collecting plant protection statistics, especially in regard to the correlation between the incidence of scab and the amount of rainfall during the 10 days previous to blossoming.

93. Based on 10-year records furnished by H.P.Gould of the U.S. Department of Agriculture the relation of general climatic conditions to blooming and ripening dates of certain fruit trees has been studied. The average date for blooming is retarded 4.6 days for each degree of latitude northerly. The greatest retardation is through the Atlantic States and least in the Pacific States. Increases in altitudes bring about a retardation of 1 day for each 101 ft. In the Atlantic and Mississippi sections the rate of retardation is not constant. It is considered that conditions affecting the rest period are involved. There is more uniformity in epochs through the Pacific States than in other regions, due to prevailing westerly winds from the Pacific Ocean. The number of days for ripening of fruit is greater in the Pacific section than in the Atlantic or Mississippi sections. The author suggests that length of day is not a factor in blooming of fruit trees. In the appendix, 46 detailed tables are given bearing on the relation of latitude and altitude to the fruiting and ripening dates, etc.

94. A remarkable phenological record kept by five generations of one family at Hevingham, near Norwich, is presented. The length of the record (190 yr., with one break of 25 yr. after 1810) is probably unique for any form of private observing. The observations include the dates of leafing of 13 common trees, flowering of snowdrop, hawthorn, etc., and the movements of 8 migrant and other birds, thus giving valuable evidence of the character of the spring months.

The data are in good agreement with those published in the Royal Meteorological Society's annual phenological reports and so provide comparable figures back to about 1745. The mean date for a group of 7 of the plant events covering the period January - May has been worked out for each year. The annual variations are closely related to temperature (indeed the correspondence between the plant - date curve and that for Greenwich mean temperature January - May is remarkable). They also show a very definite periodicity, averaging 12 yr. between unusually backward springs and early springs. Recent extreme years are:- Early 1912, 1921, Late 1908, 1917. The intervals have recently been shorter than the average, and the curves give some indications that the next late extreme is now being approached though the actual year is of course uncertain. A similar though less well marked periodicity is shown by Greenwich mean temperatures for the corresponding months January - May.

Comparing

Comparing the plant dates in the 18th and 20th centuries (taking averages for the 35 - year, periods 1751-85 and 1891-1925) of the 16 plants, 10 were earlier in the recent period, 3 were unchanged and 3 later, possibly an indication of an earlier tendency in recent springs.

Migrant birds seem independent of these conditions. The cuckoo is markedly more regular in its date of arrival than is the swallow, and its yearly variations show some relation with April temperature, while the swallow shows no such relation. (Probably the temperature of a whole month covers too long a period for this purpose). The swallow's date of arrival is definitely getting later (the average for the 35 yr. 1751-85 being 8 days earlier than for 1891-1925), in contrast to that of the cuckoo which has, on the average, kept a constant date throughout the period.

95. Calendar dates are of but little value because of variation in seasons. Phenological phenomena are governed principally by temperatures. Tables are given showing the average temperatures at which certain phenomena occur for a number of plants and animals. These are based on many thousands of observations made at 56 stations in Bavaria from 1869 to 1881, by working out the temperatures corresponding to the dates that were recorded.

96. * Results are presented for diurnal changes of chemical composition in leaf blades of the sugar mangold and sugar beet, and in the petiole and root of the latter plant.

The percentage of reducing sugars in the leaf blade increases with solar radiation, within limits. Temperature seems to be a limiting factor in the increase of these sugars when its value approaches 30°C.

The percentage of soluble protein in the leaf varies in a manner inversely related to temperature and therefore correlated with the fluctuation of reducing sugars. This constituent gave a correlation with temperature of - 0.390 ± 0.106 for periods of light and darkness combined.

The foliar fluctuations of reducing sugars are distantly paralleled by the deposition of sucrose in the root, while relatively high temperatures increase the percentage of protein stored in this organ.

The relations in the petiole are such as to suggest that a high plane of reducing sugars in the plant, together with the presence of nitrates, leads to the formation of amino acids and rest-soluble nitrogen.

These results explain practical observations, viz. that cool, fair weather, such as that common to the autumn season, is favourable to the storing of high percentages of sugar in the root of the sugar beet.

97. Series of experiments have been conducted on the relation of soil temperature and soil moisture to infection of sweet potatoes by the black-rot fungus, Ceratostomella

fimbriata

fimbriata (E. & H.) Ell. Some infection occurred at a temperature of 10°C., but not at 35°C. At temperatures between 15°C. and 30°C. 100 per cent. of the plants became diseased.

The Optimum temperature for the disease was found to be about 25°C.

Soil moisture was found to exercise considerable influence on the amount of disease. The amount of disease increased with the increase in the percentage of the water-holding capacity of the soil up to about 60 per cent. and then decreased. There was some infection in a saturated soil. It was shown that infection took place at a moisture content of the soil as low as that at which the plant would grow. Based on percentage of infected plants, 100 per cent. of the plants became diseased in soils with a water-holding capacity of 14 per cent. to 100 per cent.

Wounding is not necessary to infection, inasmuch as 48.2 per cent. of the sprouts from potatoes dipped in a spore suspension of the black-rot organism and then bedded became diseased.

Observations on the growth of control plants showed that at 10°C. the plants slowly died, and that at 15°C. no growth took place, the plants merely holding their own. The optimum for growth appeared to be at about 35°C. There was a good growth at 38°C.

98. Based on records taken on the seedlings of eight conifers, namely, Douglas fir, pinon pine and white pine. Engelmann spruce, and bristlecone pine, western yellow pine, lodgepole pine, and Norway pine, grown in a darkened greenhouse under artificial light comparatively rich in the longer wave lengths of the visible spectrum and varying in intensity from 53.5 per cent. to 1.2 per cent. during the first 6 months and from 16.6 per cent. to 0.4 per cent. during the last 5 months, there are presented the minimum light requirements for the several species. At the end of 11 months, the Douglas fir and the Norway pine seedlings were surviving in light intensities of 0.77 per cent. and 2.3 per cent., respectively, of noon sunlight on 20th September with the other species coming between in the above order.

It is believed that the comparatively low light intensities tolerated by the various species are due in part to the favourable quality and duration of the artificial light utilized. In most of the species there were seedlings well above the standards for normal growth. The pinon and other large-seeded pines grew less vigorously in the weakest light in which each species could survive than did the small-seeded species. The height of the surviving plants was not visibly affected by light intensity, but root length and branching were very markedly reduced in weak light.

In concluding, the author suggests that the lack of light in the forest is probably not the chief limiting factor in the survival of seedlings, since intensities as low as those utilized in the investigation do not often occur naturally, even under the densest canopy. Competition between species, rooting vigour and ability to survive with limited moisture are factors considered to be probably of more vital importance.

99. Chlorops taeniopus does not occur in normal years on the Baltic coast near Stettin. From 1917 it was absent until 1925, when a serious infestation of summer crops occurred. Summer oats were not attacked, but barley and summer wheat were affected. These outbreaks are attributed to the fact that the air temperatures in 1917 and 1925 were high in May and June, during which months the infestation takes place, and that these years were well below the average as regards the amount of rain.

100. Separate groups of chickens were treated as follows: (1) Raised in open sunlight, (2) exposed for 20 min. a day to rays of a quartz mercury-vapour lamp, (3) exposed only to sunlight filtered through glass. At the end of a month only those in the first 2 groups were normal, and the differences became greater as time passed. The difference seems to be determined by presence or absence of the ultra-violet rays of shorter length. Results of experiments with plants indicate that light produces a photochemical product. Only the tip of a seedling is sensitive but the bending takes place at the back of the tip, hence the product seems to be produced in the tip and transferred to older cells. Such stimulus can be carried across freshly cut surfaces. The author used original apparatus by which increases of .001 in. in length could be recorded. Growth occurred at regular and definite periods, mostly at night. Growth and differentiation are independent processes. Excess light may retard growth and increase differentiation, resulting in monsters. Less mechanical tissue is developed in absence of light. Normal growth of plants depends on ultra-violet rays as well as upon heat energy.

101. A study, in co-operation with the Lake States Forest Experiment Station of the Forest Service, of the United States Department of Agriculture, and the Wisconsin Conservation Commission, of the fire hazard conditions during the autumn and spring fire seasons in jack pine and hardwood-hemlock forest areas in northern Wisconsin is reported.

Data were collected with reference to character, amount, and distribution of the principal forest fire fuels, the effect of weather conditions on their inflammability, and the modifying effect of forest cover. The results emphasize the controlling influence of precipitation and humidity, but also indicate the relation of wind movement, sunshine, and forest cover to fire hazard.

"Two-tenths of an inch or more of rain precludes the possibility of fires for the time being by rendering the principal fuels too wet to burn. Less amounts reduce the fire hazard to a greater or less extent, depending on the amount of moisture present in the fuels at the time. Relative humidity very largely controls the rate and extent of drying out of the various fuels between rains. In dry weather, therefore, it serves as an indication of the fire hazard to be expected. In general, fires are likely to occur when the relative humidity falls below 50 per cent., while 30 per cent. and below indicates a high fire hazard. Humidity is normally highest at night and lowest between noon and 4 p.m. This explains why fires usually die down at night and burn hardest in the afternoon. In general, the humidity prevailing at 8 a.m. is near the mean for the day, while at 2 p.m. it approaches the minimum. The normal fall

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in relative humidity between 8 a.m. and 2 p.m. averages about 20 per cent. In settled weather, therefore, the humidity prevailing at 8 a.m. may be taken as an indication of conditions to be expected during the day."

The fire hazard was found to be "less in the forest than in the open and higher in pine stands than in hardwoods. Although a dense cover tends to reduce the effectiveness of precipitation by preventing about 20 per cent of the rainfall from reaching the forest floor, it materially reduces the fire hazard by slowing up evaporation".

102. In order to secure precise data in respect of the nutritive value of pasture under grazing conditions and the seasonal variations to which the value may be subject, an investigation has been carried out (in 1925) on pasturage of medium quality on a light sandy soil. Soil of this character has an extremely low water-retaining capacity, and for that reason, lack of rainfall is the factor which most frequently limits continuous productivity on such grassland.

"From the beginning of the droughty season in June up to the end of August, there appears to be a distinct correlation between rainfall and yield, the productivity of the pasture increasing or declining in the week following a rise or fall in the amount of rainfall.

"In the weeks ending 1st, 8th, 15th, 22nd and 29th June the amount of rain which fell was almost negligible, and throughout the whole of this period, and in the week following it, the weekly yield of the pasture declined steadily. A slight rise in rainfall (in consequence of a thunderstorm) during the week ending 6th July was reflected in a slight temporary rise of yield in the week following. The effect quickly disappeared, however, and following a dry week ending 13th July, the yield fell to the lowest value experienced throughout the season in the week ending 20th July.

"In the following two weeks, 0.070 and 0.072 in. of rain fell on an average per day respectively, this occasioning a marked recovery in the productivity of the pasture. The mean daily fall of 0.040 in. of rain during the week ending 3rd August was apparently sufficient to enable the recovery to continue and the 0.042 in. of daily rainfall in the week ending 10th August sufficed to maintain the yield at the new level. The decline of rainfall to 0.017 in. per day in the week ending 17th August was followed by a drop in yield during the next week from 73 lb. to 60 lb. of dry matter per acre, whereas the copious rainfall of the week ending 24th August was reflected in the rise of yield noted in the week ending 31st August.

"The results discussed above clearly point to the controlling influence of rainfall during a dry summer on the productivity of pastures on soils of low water-retaining capacity. It will further be noted that there is always a lag between the incidence of rainfall and the manifestation of its effect on productivity, a fact which has repeatedly been commented on by Stapledon. In the present investigation, the interval between an increase in rainfall and the consequent improvement of yield appeared to be about a week.

"Distribution

"Distribution of rainfall, however, whilst perhaps of primary importance in determining continuity of productivity on such pastures, is not the only factor of significance. In the months of September and October, the influence of rainfall was much less marked than in the summer period, and though a slight correlation appeared to persist in the early part of September, there was certainly no relationship of a quantitative character between changes in the amount of rainfall and in the yield.

"Towards the end of September the rise in the mean weekly day and night temperatures appeared to be directly responsible for the increase of yield in the week ending 5th October. The fall in temperature in the following two weeks was accompanied by a decreased yield over the same period. After this, rainfall and temperature cease to affect productivity, the yield at the end of the season being probably limited mainly by the diminished hours of daylight."

103. From the consideration of data on the prevalence of Dysdercus in connection with climatic conditions, especially rainfall, it appears that damp conditions generally favour infestation, and that it is only serious in regions of excessive moisture, but that the ability of Dysdercus to transmit internal boll rot is not affected by climate. A close study of records of injury by Dysdercus in the West Indies during a period of 11 yr. does not, however, support this theory, but gives evidence that serious injury usually follows a prolonged drought early in the year, and perhaps also coincides with excessive rain later in the year.

The possibility that the influence of climate on the prevalence of Dysdercus might only be indirect, through its influence on the plant, was then considered. Available evidence points to the fact that either shortage or excess of water at the roots of the cotton plant results in shortage of water in the plant tissues, causing a decline in the health of the plant and in its resistance to insect attack. In discussing the resistance of plants to insects the author points out that it is of two kinds, external, due to some character such as thickened cuticle, and internal, due to some condition of the sap. He suggests that the reason why the disturbance of the water balance in the cotton plant increases its susceptibility to insect attack may be that it renders the sap more attractive to insects by altering the concentration or constitution of the carbohydrates in it. The causes of shortage of water in the tissues of the cotton plant, excessive transpiration and defective root absorption, and the factors affecting them are discussed; poor soil aeration is an important cause of reduced root absorption, and this explains why excess of water as well as drought causes water shortage in the tissues. The chemical composition of the soil, on which depends an adequate supply of plant food, is also undoubtedly of importance in affecting the susceptibility of the soil, on which depends an adequate supply of plant food, is also undoubtedly of importance in affecting the susceptibility of the plant to insect attack.

All the factors affecting the health of a plant, are, however, interdependent, and must be studied in attempting to increase its resistance to insects, and it must be borne in mind, in this connection, that health is not synonymous with luxuriant growth.

The author

104. The author reports upon freezing-point determinations made by the thermo-electric method on oak borers, these insects having been chosen on account of their natural exposure to low temperatures. It was found that the freezing-point in the oak borer group falls in winter and rises in spring and by mid-summer very nearly reaches that of water. Hardening, or cold resistance, occurs periodically with the seasons out of doors, but can be induced or broken up by exposure to certain temperatures or moistures.

105. *The common bean weevil, Bruchus obtectus, Say, has been used for experiments on supercooling and resistance to low temperature. Bachmetjew has made the most extensive contributions to the subject of vital temperature in insects, and this study follows in a general way the lines laid down by him. While he believed that an insect's temperature must be lowered again to its supercooling-point after a rebound has taken place before death ensued, subsequent works show that an insect is killed if a rebound occurs. A rebound is evidence that heat of crystallization is given off. Crystallization of the lymph is believed to be responsible for the death of the insect.

Comparing differences between individuals it is found that pupae show more variation from the average trend. This is explained by the fact that pupae of all ages were used, and the physical properties of their lymph varied.

It has been seen that larval, pupal, and adult, weevils could withstand lower temperatures when cooled uninjured than when the point of a thermo-couple was thrust into them. Active adults withstood temperatures of -10°C. a temperature below the average supercooling-point, for a period of 3 hours. Pupae and advanced larvae withstood the same temperatures for 7 hours.

It has not been found possible to obtain the exact freezing-point of B. obtectus with present-day electro-thermal methods.

There is a distinct correlation between the supercooling-point and the rebound-point, but this is believed to be due to radiation from the insect to the air of the cooling chamber. The exact freezing-point is actually much higher, than, than the rebound-points recorded.

The temperature-time experiments show that time is a factor in the resistance of B. obtectus to low temperature. It is apparent, with freezing-points as high as those of this insect must be, that supercooling takes place at temperatures of -10°C. or below. That being the case, the data imply that supercooling is possible for limited times only at certain temperatures.

The relationship between supercooling and the rate at which the insect has cooled has been studied. There

seems

seems to be no correlation between these two factors.

A condition of post-freezing development with ultimate death has been observed at temperatures just below the limits of resistance. This has been referred to in this paper as arrested development. It is manifest in the adults as failure to emerge, due to the loss of the insect's capacity to cut its way out of the bean; pupae can metamorphose only to adult form in the head and thoracic regions, the abdomen remaining undeveloped; larvae are unable to emerge from the egg, or, if they do emerge, it is often through the side of the egg, not through the operculum. Many that emerge from the egg are unable to enter the bean.

The limits of the fatal temperature-time zones have been determined for four stages of B. obtectus. This insect apparently has no capacity for hardening.

The thermal constant, as descibed by Sanderson and Pearis has not been worked out for this insect. A difference of less than 10°F. - the difference obtaining between the temperature of the laboratory and a cool, dry basement at about 64°F. - almost doubles the length of time required for a complete life cycle. This means that even in the South development of the insect could be retarded considerably until fatal outdoor temperatures prevailed.

106. The author described a set of air-control chambers suitable for conducting experiments on the relation of plant disease to environment. These are said to have been in operation for five years, with but few repairs and to have given satisfaction in experimental work.

107. The results of a field study, made at Beebe, Arkansas, in 1923 and 1924, on the correlation between weather conditions and the incidence of leather rot (Phytophthora cactorum) and other rots of strawberries indicate that rainfall and temperature are decisive factors in the development of these diseases, which develop with severity when a rainy period during the picking season is followed by warm weather, whereas if the rains are followed by cool weather, there is less danger of rot.

108. After a general discussion on the importance of meteorological conditions in relation to plant diseases, and on the necessity of a scientific basis for crop improvement, the writer describes the uses of the Wisconsin soil temperature tanks in the study of fungous infection and the testing of resistant varieties. The correlation between the incidence of various diseases and soil and temperature conditions is illustrated by references to seedling blight of wheat and maize (Gibberella saubinetii), oat smut

(Ustilago

(Ustilago avenae and U. Levis), and stripe disease of barley (Helminthosporium gramineum) as affected by climatic factors. The incidence of stripe was more than doubled in 1925, when the soil was cool and wet, as compared with 1922, when the seed was sown in moderately dry soil. The best temperature for the growth of barley seedlings appears to be 55°F. The amount of oat smut in plots sown in moist soil (which subsequently became dry) at 60°F. in 1923 was 56 per cent. compared with only 1 per cent. in moist, cool soil at 52°F. in 1925.

109. *General observations pointing toward climate as one of the limiting factors in the distribution of the root-knot eelworm have been justified by a few definite experiments.

The results of the soil temperature experiments are evident and conclusive. Below about 15°C. the amount of root knot is substantially less than it is at only 2°C. or 3°C. higher and 3 degrees lower yet it is almost eliminated and practically negligible. At 10°C. and 12°C. infections are very rare. Different crops vary to some extent in amount of infection at points near the critical temperature. Tobacco shows the change very abruptly, from the lower to a higher temperature whereas with soy bean the change appears to be more gradual. With both, the critical temperature is much below the optimum for growth. With crops whose range of good growth includes the critical temperature, the differences in root-knot development are striking. At the higher temperatures root-knot is abundant up to a temperature as high as the highest temperature at which the plants will grow. There appeared at times to be a dropping off of amount of the disease above 30°C. but this was usually traceable to a decrease in available root growth, rather than an actual decrease in proportion of affected roots.

The similarity in effect on all the plants studied, high-temperature-loving and low-temperature loving plants alike, lead to the belief that the reaction to temperature is on the part of the parasite rather than the host. Differences in type of knots are produced at different temperatures, to be sure, but there again at least a part of the difference is due to differences in stage of development of the eelworm.

* * * *

The amount of moisture seems to play only a small part in root-knot development, so long as the moisture content of the soil is favourable to the growth of the crops. Within the range of 40 per cent. to 80 per cent. of the moisture-holding capacity of the soil there is very little difference in root-knot development. At 60 per cent., 70 per cent. and 80 per cent., there appears to be a slight increase over the other percentages. Even below 40 per cent. which is too dry for good growth of ordinary crops, and above 80 per cent. which is more or less muddy, considerable root knot occurs.

110. In continuation of his previous investigations the

writer

writer has made a further study of the changes induced in the tissues of crown gall tumours due to Bacterium tumefaciens in Pelargenium plants by the action of X-rays.

It was found that irradiation of such tumours caused the formation, in the body of the tumour, of distinct spherical zones composed of living cells, with a large nucleus or sometimes several, protected by a covering of dead cells. These arise from the meristem of the tumour which, under the action of the rays, considerably modifies its ordinary type of proliferation.

The death of the tumour from irradiation is a result of the excessive proliferation of the small cells and the accumulation of starch by the large ones.

111. In 1928, the Montmorency cherry trees in western New York suffered defoliation to a considerable extent as a result of a physiological disease known as yellow leaf, or a leaf spot caused by Coccomyces hiemalis. Variation in leaf cast was noted on trees in the same orchard, the more vigorous ones showing the least defoliation. Studies on the control of the leaf spot by means of lime sulphur, with and without lead arsenate, showed that an application 10 days after petal fall should be made to avoid the risk of defoliation by the leaf-spot fungus. Where the fungus was controlled, defoliation by yellow leaf was observed, especially on the less vigorous trees, and a close relationship was found to occur between this type of defoliation and winter injury of the roots. The relation of defoliation of trees to their vigour was investigated. In some cases branches were winterkilled that had an insufficient amount of stored food material. The winter injury in 1928 is considered to have been associated with defoliation caused by the leaf spot. In general, the later in the season that defoliation occurs, the less injury to the following crop.

112. In February, the authors presented to the Academy strawberries grown artificially in a closed room under the influence of heat rays, light rays, and ultra-violet rays up to 3100 A. The plants had been brought in frozen on the 12th December, 1928: 40 days later, the fruits had matured. The leaves possessed the normal amount of chlorophyl, and the tissues the usual thickness.

According to the authors, the rays beneficial to vegetation range between 4750 A. (in the blue) and 6500 A. (in the red): when the ultra-violet (below 4000 A.) is eliminated the vegetative cycle proceeds more easily.

The apparatus is simple: two 1200 Watt (24 Amps under 50 volts) lamps (tungsten filament in a mixture of nitrogen and argon) furnished with reflectors fixed at the ends of an horizontal bar are given a continual gyratory movement. The plants are placed 1.20m. below the lamps on the circumference of a circular platform.

The rate of production is doubled.

113. * 1. The adaptation of plants to resist frost appears to depend on seasonal changes which give the protoplasm stability. A study has been made of the changes occurring in winter wheat plants, of varieties differing widely in winter hardiness, during the autumn and winter months.

2. By analysing the press-juice as well as the entire tissues at progressive dates, it has been possible to study the distribution of the more important constituents between the physiologically active cell fluids and the relatively inert supporting framework.

3. One of the most important changes in the quantitative relations of the various plant constituents is the reduction in moisture content. This takes place to a greater degree in hardy varieties. The resulting concentration of colloids and sugars in the cell fluids increases the resistance to freezing.

4. Proteins constitute the bulk of the cell colloids, about 90 per cent. of the total protein of the plants being contained in the fluids. Pentosans are restricted almost wholly to the structural parts of the plant, although pentose sugars are present in small concentration in the fluids. The ash is mainly contained in the fluids.

5. Sugars accumulate in all varieties in the autumn, but in general reach and maintain a higher concentration in hardy varieties. As sugar protection against frost denaturation of the proteins increases with concentration, the hardy varieties are given an important advantage.

6. Lipoids do not appear to play an important part in the physiology of frost resistance in wheat.

7. Amino-nitrogen and non-coagulable nitrogen increase as the season progresses, but no correlation has been found between the apparent degree of protein-splitting and the relative hardiness of varieties.

114. In 1924 and 1925 the author conducted a series of experiments in constant temperature tanks, fitted with an electrical apparatus enclosed in waterproof brass containers, to ascertain the effect of soil temperature and soil moisture on the incidence of head smut of sorghum (Sorosporium reilianum). In 1924 the temperature range was 16°C. to 34°C. and in 1925 12°C. to 36°C. In the latter test the moisture content of the soil on an oven dry basis was 15 per cent. in half the cans in each of the tanks, and 25 per cent. in the other half. Smut spores and cultures of S. Reilianum were thoroughly mixed with the soil.

Sorghum seedlings became infected at temperatures from 16°C. to 36°C., the highest percentage of smut (38.35 and 46.50 in 1924 and 1925 respectively) occurring at 28°C. The lower soil moisture was much more favourable to infection than the higher, no smut development occurring at 16°C. under the latter conditions and comparatively little at higher temperatures. The thermal range for infection coincides fairly closely with that for the optimum development of the pathogen in culture as determined by Potter, namely, 28°C. to 30°C.

There was no correlation between the rate of germination of the sorghum seed and the percentage of smut which developed. Germination was most rapid at 34°C. to 36°C., while the plants grew best at 28°C. to 36°C. These data are thought to indicate that soil temperature and soil moisture determine the amount of smut by direct action on the pathogen rather than by indirect influence on the host.

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A low percentage of infection appears to be associated with low temperature and high precipitation. In Minnesota the optimum temperature for spore germination, sporidial production, and seedling infection seldom occurs at planting time.

115. *The occurrence of dense forest growth in regions of heavy rainfall, and the humid atmosphere and damp soil which prevail in many forest regions suggest a relation between forests and rainfall which has often been construed to mean that forests cause the quantity of rain falling in their immediate neighbourhood to be larger than that falling on a corresponding area on which no trees are growing.

In order to ascertain whether there was evidence of any relation between forests and atmospheric and soil moisture in India, the Government of India carried out an exhaustive enquiry during the ten years from 1906 to 1915. The results were published in Forest Bulletin No.33 (Calcutta 1916) where it is stated that the influence of forests on rainfall is probably very small. In 1910 the United States Weather Bureau published a report on "The Influence of Forests on Climate and Floods" in which the opinion is recorded that forests have little or no effect on the quantity of rain falling. Similar conclusions have been reached by other investigators working in other regions.

It is now generally recognised that rain falls continuously when a current of moist air flows into a region where it comes under reduced atmospheric pressure; the expanding air is unable to contain all the water vapour so that a proportion of it is condensed to form clouds and finally rain. Such conditions occur when a moisture-laden current of air striking against a hill range is deflected upwards into higher altitudes. So long as the supply of moist air is maintained rain will continue to fall. But such conditions are not provided by forests. Forests on a hill-side may gain by the heavier rainfall on that slope which is the more exposed to moist air currents, and tropical forests flourish in the heavy rainfall provided by the upward movement of masses of moist heated air near the equator, but the forest is not the determining cause of the precipitation.

Forest covered hill-tops standing in a moist air current will often cause an appreciable amount of water to become available by condensation which on a bare hill-top would probably evaporate in the drier air on the leeward side of the hill, but forests alone cannot provide the energy needed to raise a moist air current to such an altitude as will ensure a proportion of its moisture being precipitated as rain. A hill range whether forested or not may do this as also may a colder current with its greater density pushing under a warmer current and raising it; either of these can and do provide that continuance of suitable conditions which results in a steady rainfall. There is nothing which forests possess which can produce like results.

116. *Improvements in apparatus for control of environmental factors in plant growth are described, together with methods of estimating the total illumination effective from sun and electric lamps. Results are given of 9 series of wheat cultures in water, sand, and soil. Each series was subjected to 2 planes of temperature, but with illumination and atmospheric humidity uniform. Atmospheric humidity exercises

little

little influence on the protein content of wheat during seed development. With illumination probably deficient in intensity, lower temperature favoured the production of dry matter, as if conserving limited supplies of photosynthetic products. Under these conditions the lower temperature generally favoured both the percentage and yield of protein in the tissues. The failure of seed formation in plants thus closely confined is chiefly due to unfavourable conditions for pollination. With illumination probably adequate in intensity, young wheat plants contained greater percentage of sucrose and protein when grown at lower temperature. Mature plants contained increased percentage of carbohydrates and gave markedly increased yields, especially of grain, at the lower temperature. The higher sugar content at lower temperature appears to favour protein synthesis, but at higher temperature deficiency of nitrate supply seems to operate as a limiting factor. Although the amount of protein synthesized is less at the higher temperature, its percentage in the tissue is increased, apparently because of greater respiratory loss of carbohydrates than at the lower temperature. To explain these effects, the conception is advanced that there is a critical balance between the temperature responses of photosyntheses and respiration.

117. With reference to the negative results obtained by Miss Löhnis in her investigation of the relation between meteorological conditions and potato blight (Phytophthora infestans) the writer points out that insufficient attention was paid to the combined influence of several factors operating simultaneously. As shown by Roussakov the occurrence of night dews is an important factor in the development of fungous diseases. The four requisite conditions for the development of late blight are stated to be: (1) night temperature below the dew point for at least four hours; (2) minimum temperature not below 10°C.; (3) mean cloudiness the next day not less than 0.8; and (4) rainfall during the next 24 hr. at least 0.1 mm. Among the 30 dates of outbreak of blight during 1919 to 1923, 29 were preceded within 15 days by a day fulfilling the four conditions, and after 1st May only five such days occurred which were not followed by infection within 15 days.

Certain discrepancies in the data relating to the incubation period of the disease are discussed, and proposals are made to supplement the available evidence by providing for meteorological observations on potato fields, and by the application of control measures only after days fulfilling all the above-mentioned conditions.

118. An unexpected drying out of wet soils was noted when they were placed in desiccators over water on a constant temperature bath.

Several absorption experiments were carried out in an apparatus designed so that it was possible to determine the amount of water absorbed at any time without opening the desiccator or removing it from the bath.

The

The amount of water absorbed from a saturated atmosphere when the desiccator was kept dark exceeded twice the so-called "hygroscopic coefficient". When a beam of light was turned into the desiccator all the soils dried out to a moisture content equivalent to about 84 per cent. of their maximum vapour pressures. When the lights were turned off the soils began to absorb moisture again, showing that light absorbed by the soil caused the drying out noted.

A thermo-couple was used to measure the difference in temperature between a soil and water in a submerged desiccator. The difference was found to be 4.5°C. when a 300 c.p. light with a reflector 50 cm. away was used, 0.5°C. when the reflector was removed, 0.16°C. due to the laboratory light during the day and within the experimental error at night.

To make sure that there could be no isothermal equilibrium between relatively dry soil and a saturated water vapour it was shown by geometry and mechanics that, at least for uniform spheres, such an equilibrium would be impossible.

A general discussion of potentials is given and four are defined, viz. The gravitational, pressure, osmotic, and total potentials. The relationship between the sum of the osmotic and pressure potentials in a liquid and the equilibrium vapour pressure is derived.

The forces that exist between wet and dry soils in contact are shown to be enormous, by calculating the pressure potentials from vapour pressure data. The relationship between these two functions is derived.

119. * Data from records of a Cheviot and a Blackface flock kept under similar conditions for the period 1911-1924 were examined, together with meteorological data for November-December and April-May for the period 1910-1924. Analyses of these data indicate that:

(1) Using the figures for lambs percentage as measures of fertility, there is a significant difference between the two breeds under the same conditions and therefore a differential breed response to causes affecting fertility.

(2) Any external influences which affect lambs percentage in the Cheviot do so chiefly through their effect on Eild percentage while in the Blackface lambs percentage is influenced either directly by other factors having no effect on eild or by the same factors to a greater extent.

(3) The differences in infantile sex-ratio between the two breeds are not significant; and the year to year variations are also not significant, but the possibility of a selective elimination of one sex by infantile mortality is not excluded by the fact that the data here discussed do not provide significant associations between infantile sex-ratio and other variables.

(4) No measures of infantile mortality before the end of the lambing season can be derived from the data, but figures

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for mortality between the end of lambing and castrating time indicate that for this period there is no significant difference in lamb mortality between the two flocks; the same causes of mortality are apparently at work in both flocks during this period.

(5) For conditions of mean daily temperature and daily range of temperature at tupping time no definite conclusions can be drawn, but there may be some slight association between high mean temperature and high yield in the Cheviot flock and low yield and high daily range of temperature in the Blackface flock.

(6) Rainfall in inches or number of rainy days at tupping time have no significant association between high mean temperature and high yield in the Cheviot flock and low yield and high daily range of temperature in the Blackface flock.

(7) Mean daily temperature at lambing time is of no importance but there is significant evidence that a low mean daily range of temperature is associated with a low lambs percentage and a high eild, and vice versa, in both flocks. It is concluded that in the Blackface flock mean daily range of temperature has no effect on lambs percentage except in so far as it affects eild, but in the Cheviot flock it may have some direct influence on lambs percentage.

(8) The rainfall in inches at the lambing time has no effect on lambs percentage but the number of rainy days is the most important meteorological factor influencing lambs percentage and eild in both breeds, most probably through its effect on early post-natal mortality. A high number of rainy days is associated with low lambs percentage, and high eild and vice versa but while this and other meteorological factors do influence lambs percentage in both breeds, there being differential responses, the reasons for differences in the yield of lambs in the two flocks are due chiefly to inherent breed characteristics.

It should be noted that the figures here obtained for lambs percentage, sex ratio, and percentage "eild" are not necessarily indicative of the conditions in either of the breeds generally, but relate only to the conditions peculiar to the two flocks considered.

120. * Infection of corn by Diplodia zeae (Schw.) Lev. is generally effected through the tip of the ear.

The degree of infection of the ear and of the kernel varies.

The length of life of the seedling or of the plant depends upon the degree of initial infection in the kernel.

The severity of the attack on corn by Diplodia increases with rise in temperature.

Corn is more susceptible to Diplodia and to smut at higher temperatures.

The

The cardinal temperatures for the development of Diplodia parallel the cardinal temperatures for the development of corn.

Diplodia has a wider range of temperature for its development than has corn.

The decrease in yield as seeding was delayed, as far as the experiments reported here are concerned, is due more to the reduction in stand than to the reduction in size of the ear due to lateness of planting.

Plants on the diseased plots were more variable in height than were plants on the disease-free plots.

The death of corn caused by Diplodia generally takes place in the plantlet stage.

Plants that escape the Diplodia attack in the early stage develop just as normally as do disease-free plants.

Leaning and fallen plants, production of suckers, and production of brace roots are not conclusive evidences of root destruction caused by root-rot organisms.

The relationship of temperature and moisture to the growth of diseased and disease-free corn follows the law of limiting factors.

121. * The moisture absorbing capacity of shelled corn varied with the relative humidity.

The effect of temperature upon the moisture absorbing capacity of corn at relative humidities between 10 per cent. and 90 per cent. was negligible.

Above 90 per cent. relative humidity, the moisture content of corn was greatest at the highest temperature.

Below 10 per cent. relative humidity, the moisture content of corn was greatest at the lowest temperature.

Since a rise in temperature increases the moisture absorbing capacity of the air, it is deemed advisable to apply artificial heat together with ventilation on cold winter days to maintain a low moisture content of corn in seed corn storage houses.

122. * A recent review and recalculation of published energy metabolism work of the Institute of Animal Nutrition, Pennsylvania State College has brought to light the fact that in one experiment at least, and perhaps in others, there was a confusion of heat produced from the feed with heat produced from the katabolism of body tissue, by reason of the fact that the shearing of the steer which served as the experimental subject had the effect of raising the critical temperature

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for the animal above the temperature of the chamber of the respiration calorimeter.

A steer receiving as much as 2.933 kgm. of dry matter of feed per day may find a temperature of 19°C. below its critical temperature if the animal has been sheared.

In a fasting experiment, with a steer, beginning four days after the last feed was given, the heat production on the first day of observation - that is, on day 4 to 5 after feeding- was found to represent essentially the true fast.

In the case of a fasting steer, shorn of its coat of hair, weighing 339.6 kgm. to 330.5 kgm., at environmental temperatures of 13.68°C., 15.70°C., 18.26°C. and 22.06°C., the 24-hour heat production was, respectively 8,243 calories, 7,989 calories, 7,519 calories, and 6,806 calories, showing that at least the first three temperatures were below the critical for this animal.

(With a fasting steer carrying a full coat of hair, weighing 356 kgm. to 349 kgm. and exposed to environmental temperatures of 15.54°C., 18.46°C., 21.51°C. and 14.16°C., the corresponding 24-hour heat production was 6,322 calories, 6,430 calories, 6,453 calories, and 6,180 calories, respectively, at least the first three temperatures being above the critical. The data suggest that at these temperatures there may have been a slight expenditure of energy by the animal in keeping cool.)

With both the shorn steer and the steer with a full coat the percentage of the heat emission as latent heat of water vapour increased with the increase in temperature, this effect being much more pronounced with the steer having the full coat of hair. Conversely, the percentage of the heat emission lost by radiation and conduction (combined) decreased with increase in the temperature.

The average heat production of a fasting steer with its full winter coat was 18.01 calories per kgm. of live weight and 1,457 calories per sq.m. of body surface.

The decrease of heat production per degree centigrade of rise in temperature below the critical was 36 calories per sq.m. of body surface.

The practical significance of this fact, which is so clear as to require no special demonstration, is that under the usual conditions of intensive cattle feeding, where feed and shelter are to be had at reasonable cost, it is more profitable to keep the animal above the critical temperature than to force it to burn extra feed or to draw upon body reserves of energy in order to keep warm. Whatever the conditions as to profitable practice, however, it is important to know that a fall of 1°C. in temperature below the critical increases the cost of maintenance of cattle by about 2.5 per cent.

123. * From a curve it is shown that there is a higher mean minimum temperature over shingle than over grass during the

period

period March-August, and vice-versa during the period September-February. The one exception ot these statements is the July reading, which gives a slightly higher reading over grass than over shingle when, from the general run of the figures, one would have expected the reverse.

The results would appear to establish that on the average:-

(1) At night during the period March-August the air directly over shingle was rather warmer than that over the grass.

(2) At night during the period September-February the air directly over grass was warmer than that over shingle.

(3) At night for the year as a whole the air directly over shingle was slightly colder than over the grass.

The explanation of the results involves several factors, but no doubt the main one is the radiation effect in relation to long and short nights. Shingle takes up and gives out heat quicker than turf. During the period of long days and short nights (viz. March-August) the time of taking up heat is longer than the time of giving it up, and the actual balance of heat at night is with the shingle. During the period of short days and long nights (viz. September-February) the balance is with the grass.

124. * The temperature range for the growth of Ceratostomella fimbriatum on sweet-potato agar extends from 10°C. to 34.5°C.

The optimum, maximum, and minimum temperatures for the growth of the fungus are 23°C. to 28.5°C., 34.5°C. to 36°C., and 9°C. to 10°C. respectively.

The range of temperatures at which Ceratostomella fimbriatum will infect sweet potatoes extends from 9.5°C. to 34.5°C. corresponding closely to that of the growth of the pathogen. The fungus seems to die out at a temperature of 9.5°C.

The optimum, maximum and minimum temperatures for infection and the development of the disease are: Optimum, 23°C. to 27°C.; maximum, 34.5°C. to 36°C.; and minimum, 9°C. to 10°C.

The number of infections that will occur between 9°C. and 11°C. is small.

The temperature range at which it has been shown that black-rot lesions will enlarge is from 6°C. to 33.5°C.

The rate of enlargement is slow between 6°C. and 14°C. and increases very rapidly above 14°C. until it reaches a maximum between 23°C. and 27°C. It varies greatly at any given temperature and in some instances ceases altogether.

The number of infections is governed by the temperature which prevails during the early stages of infection (11 days). The number of infections increased from 22 at 14°C.,

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the minimum for this period, to a maximum at temperatures near the optimum for the development of the disease (20°C. and 23°C.). With a further rise in temperature the number of infections decreased to 3 at 31.5°C. and at 33°C. ceased altogether.

As the experimental period was extended from 11 days to 21 days the influence of temperature on the number of infections became less apparent, except at the border temperatures. The differences in the number of infections at temperatures of 14°C., 18°C., 20°C., 23°C., 23.6°C. and 28°C. are relatively small.

125. * The growth of the white rot organism (Sclerotium cepivorum Berk.) on potato dextrose agar occurs from somewhat below 5°C. to about 29°C. The most rapid development takes place between 20°C. and 24°C. whilst it is nearly as great at 15°C. to 20°C. after a somewhat longer period of time.

Infection occurs readily and the disease progresses most rapidly at soil temperatures between 10°C. and 20°C. At 20°C. and 22°C. there is a marked reduction in infection, and at constant temperatures of 24°C. or above, the disease does not appear. This temperature reaction holds for three varieties of common onion: multiplier onion, Welch onion, and garlic.

In the soil used, the greatest development of the disease occurred when the soil moisture was kept at about 40 per cent. of the water-holding capacity. At 20 per cent. of the water-holding capacity the growth of the host was very slow and the amount of disease was reduced. At 60 per cent. and 80 per cent. of water-holding capacity the growth of the onion plant was accelerated but infection was greatly reduced.

It is pointed out that, under natural conditions variations in soil moisture may have a direct effect upon the occurrence of the disease. In the northern onion-growing sections of the United States the most favourable soil temperatures occur during the first half of the growing season while during the last half the daily mean soil temperature for the upper layers of soil is, for the most part, above the point most favourable for disease development (10°C. - 20°C.). In the more southerly sections, where winter crops of onion and related plants are commonly grown, the favourable temperatures probably extend over a long portion of the growing season.

126. * The general climatic features of this region (Akron, Colorado.) make the amount of seasonal or annual precipitation the limiting factor for successful crop production. Regions of less variability of precipitation generally produce larger crops and also smaller variations in the yields.

In regions of generally adequate summer precipitation (Ohio, for example) winter wheat averages 18 bus. per acre, while at Akron the average is only 12.8 bus. per acre. Spring wheat averages 15.6 bus. per acre in Ohio, but only 10.3 bus. per acre at Akron. Oats in Ohio average 37.8 bushels per acre; at Akron, only 22.4 bus. per acre.

Barley

Barley was 28.4 bus. per acre in Ohio and only 20.3 bus. per acre at Akron. Maize shows plainly the difference in results where generally adequate moisture prevails and where it is only barely sufficient at best. In Ohio it averages 38.9 bus. per acre; at Akron, 14.6 bus. per acre. These averages for Ohio, it must be remembered, are for the whole State, while at Akron they are for a limited area and produced under the very best cultural methods known to Science and under constant and direct supervision of highly trained agriculturists. From these few data it will be seen that the moisture, while it is evidently of major importance at Akron, is probably not the most critical factor in more humid regions.

This study indicates that growing crops suited to dry land under conditions such as exist at Akron is decidedly precarious and this holds for large areas of the drier sections of the United States. Of the five crops considered in this paper winter wheat alone showed an even chance of giving an average yield; it varied above normal eight times and below seven. Spring wheat and maize averaged above normal 40 per cent. of the time, whilst oats and barley averaged above normal only 33 per cent. of the time.

127. * The data recorded in this paper, and those obtained from other experiments, show that infection of sweet potatoes by Rhizopus occurs almost exclusively through fresh wounds.

The optimum relative humidities at a temperature of 23°C. for the infection of halved roots of sweet potatoes by Thizopus range from 75 per cent. to 84 per cent.

The percentage of infection decreases rapidly as the humidity is raised above or lowered below the optimum humidities.

This decrease is more consistent above the optimum than below it; i.e. there is less variation in the number of infection above the optimum than below it.

Very few infections of halved roots occurred at relative humidities of 93 per cent. to 99 per cent. at a temperature of 23°C.

Very few halved roots which had been subjected to relative humidities of 89 per cent. to 97 per cent. (temperature 23°C) for a period of 4 days to 12 days became infected when they were retained at these humidities for another period or were placed at humidities of 48 per cent. to 89 per cent.

On the other hand, a high percentage of the halved roots which were subjected to relative humidities of 51 per cent. to 73 per cent. for a period of 4 days to 12 days became infected when they were placed later at relative humidities of 84 per cent. to 95 per cent.

Halved roots that had been exposed to relative humidities of 51 per cent. to 52 per cent. for a period of 9 days to 12 days did not become infected when they were subsequently placed at relative humidities of 48 per cent to 73 per cent.

A resistance to infection by Rhizopus developed in the halved roots that had been held at relative humidities of 89 per cent to 97 per cent.

This resistance is located in the surface layers of the wounded areas and has a possible relation to cork formation.

The Yellow Jersey, Big Stem Jersey and the Porto Rico varieties of sweet potato responded in a similar fashion (within the range of humidities used in each case) to the action of air moisture.

The Yellow Jersey variety was kept for periods of 56 days to 150 days during three seasons with only a few infections with Rhizopus occurring.

128. #1. Experiments by Trumpf, and in the Botanical Laboratory at Leeds, are described, which serve to show that in certain species etiolated plants are very sensitive to daily exposures of light of only a few minutes duration, marked morphological changes in the shoot appearing as a result.

2. In the light of this observation many contradictions in the literature of etiolation upon questions of fact are readily elucidated.

3. Any explanation of the morphological changes produced upon etiolated plants by light which is based upon the effect of photosynthetic products is also eliminated.

4. It is pointed out that the light action would appear to be photocatalytic and produced upon products of metabolism in the shoot, not upon the living metabolic machinery itself.

129. #1. The general plan of the anatomy of the seedling of Vicia or Pisum remains unaltered by growth in darkness, but the third and further internodes usually fail to develop, the third remaining curled in the plumular hook.

2. The diameter of the stele relatively to the stem is smaller in the etiolated plant and though considerably expanded after one hour's exposure to artificial light each day is still slightly smaller than in the normal plant.

3. In the root the stele is limited upon differentiation by a primary endodermis, in the shoot in the dark it is bounded in the first place by a starch sheath which is later replaced by a primary endodermis. A starch sheath is never present in the roots of Pisum and Vicia.

4. A striking but fugitive staining reaction is described, given by the protoplasts of the layer limiting the stele when sections from the living etiolated plant are transferred direct to Nile blue sulphate in glycerine. From the behaviour of the layer to osmic acid reagents also, this staining reaction would appear to be due to fatty substances. The reaction disappears in steams exposed even to very brief daily light exposures.

5. It is impossible to plasmolyse the differentiated cortical cells of plants grown completely in the dark, but after very brief daily light exposures these cells plasmolyse readily.

6. The cells just below the meristematic apex are packed with starch in the etiolated shoot although the reaction with iodine reagents is not good until after treatment with alcoholic potash. This starch disappears very rapidly, except from the starch sheath, upon brief exposure to light.

7. The plumular hook is shown to be associated with the leaf habit of the plant, as leaf habit is correlated with the vascular supply and the outer side of the hook is characterised by the greater vacuolation of the cells upon the side of the stem in which the vascular elements of the stele are most fully developed. When leaves arise in pairs on opposite sides of the stem, the shoot does not form a plumular hook when grown in the dark.

8. The facts summarised above are shown to be consistent with the conclusion that the main morphological and structural features of etiolation are determined by a redistribution of meristematic growth at the shoot apex, consequent upon the greater difficulty experienced by the meristem in drawing nourishment from the vascular supply because, when growing in the dark, the walls between vascular strands and meristem are rendered relatively impermeable by the retention in them of the protein and fatty substances that form the surface of the protoplast.

130. *1. Blaauw explains the positive phototropic response of the etiolated shoot as the result of the slower growth of the side towards the light.

2. The previous studies in etiolation show that this slower growth under illumination is to be explained as the result of a redistribution of growth. The photo-chemical action of the light releases protein and fatty substances from the walls of the cells intervening between vascular bundle and meristem; as a result the meristem cells at the surface of the shoot are able to grow freely and a more superficial tissue growth takes place, instead of the almost exclusive growth in length which occurs in the etiolated shoot.

3. The light quantities required to produce phototropic curvatures in an etiolated shoot are very small, as are the light quantities required to modify its rate of growth.

4. The normal light-grown shoot is much less sensitive to light. Phototropic curvature, if it occurs, can only be induced by prolonged and strong light exposure.

5. The possible effect of such strong lateral light upon the growth of the normal shoot is discussed. Such light may induce phototropic curvature by its influence upon the nutrition and extension of the cells at the growing point. This phototropic mechanism must be sharply distinguished from that operating in the etiolated shoot.

6. Blaauw's experimental results upon the phototropic curvature of the sporangiophore of Phycomyces are briefly re-capitulated. Light is concentrated by lens action upon the side of the wall distant from the laterally placed light source, this side therefore becomes more extensible as the result of photo-chemical changes, and its greater extension leads to a positive phototropic curvature.

7. In the light of these experiments a new explanation of the negative phototropic curvature of light-sensitive roots is advanced. It is attributed to the quicker extension of cells which are just commencing to vacuolate as the result of their stronger illumination.

8. On the other hand, the slower rate of growth of these roots in the light is explained as due to the fact that in the light the cells of endodermis and cortex finally attain a shorter adult length,

9. Most roots are not sensitive to light. The difference between shoots and roots in this respect follows naturally from the different dispostion of the meristematic tissues at the growing points.

131. #1. Recent experiments with the coleoptile in which the apex is replaced upon the decapitated stump are supposed to demonstrate that lateral light falling upon the apex causes the production or release of growth-regulating substances which diffuse to the lower part of the coleoptile and there cause phototropic curvatures.

2. Such an experimental demonstration of the reception of a tropic stimulus in one region, followed by tropic response in another, is fully established, excludes the possibility of explaining phototropic curvatures as a simple "light-growth" reaction such as is suggested by Blaauw.

3. But when the numerous facts as to the conduction of phototropic curvature from the decapitated apex are considered it is found that their explanation in terms of the classic theory of stimulus and response entails numerous difficulties and some of the assumptions made at present are mutually inconsistent. The facts are, therefore, reconsidered after the structure and growth of the coleoptile has received fuller elucidation.

4. This organ possesses limited growth and during the period it is employed in phototropic experiments its increase in length is entirely by cell extension; no new cells are formed.

5. This process of cell extension proceeds more rapidly in light, but the cells do not stretch so much; in the light therefore the coleoptile grows more rapidly but its final length is less.

6. The frequent occurrence of apical guttation is recalled, it is shown that the localisation of the apical

hydathode

hydathode explains the direction of the usual autonomous curvature of the coleoptile.

7. The permeability of the coleoptile tissues are increased by light, and therefore light falling on the apex increases the apical guttation.

8. Lateral light falling on the apex therefore increases the rate of flow from the vein nearer the light and thus produces a phototropic curvature.

9. When the apex is removed, guttation is very free and growth much reduced until the cut surface is blocked.

10. If the apex is replaced immediately, the guttation is reduced and growth is greater. If the apex is replaced on the side of the stump only, this side only is blocked and curvature results.

11. From the same standpoint the different curvatures produced by the asymmetric replacement of an apex or a ring of coleoptile tissue are explicable.

12. If the replaced apex is laterally illuminated the block is less complete on this side of the stump and positive tropic curvature results.

13. The various facts at present elucidated by investigators, as due to growth regulation by substances diffusing from the apex, are passed in review from this new standpoint, and appear to be consistent with it.

14. On the other hand the fact of the upward flow of guttation, reported by nearly all experimenters with decapitated coleoptiles on which tips are replaced, is not easily reconciled with the idea of the downward diffusion of growth-regulating substances.

15. It is then shown that an interpretation of the phenomena of phototropic curvature in the coleoptile which is consistent with the "light-growth" hypothesis of Blauuw can be applied with less difficulties and fewer inconsistencies than any interpretation yet attempted on the lines of stimulus and response.

132. * The beneficial effect of ultra-violet irradiation in certain conditions of malnutrition and the associated diseases has been conclusively proved, and the clinical application of this remedy in human medicine is already very

wide.

wide. Farm animals with their enormous capacity for transforming food which is of little direct use to human beings into products of the highest nutritional value, are particularly prone to diseases of malnutrition. While it must be recognised that against such the first line of defence is an adequate and well-balanced diet, ultra-violet light has been shown to be a most valuable adjuvant.

Its effects are most marked in those conditions in which there is a strain on the calcium and phosphorus metabolism. Examples of such are growth, rickets, pregnancy, lactation, laying. Experiments are described which show the value of irradiation in several of these conditions.

It is suggested that there should be a fuller utilisation of sunshine for farm animals, and the employment of artificial means of irradiation in winter is put forward as worthy of trial.

The agriculturist should realise that the beneficial influence of sunshine falls not alone upon his crops but upon all farm animals. There is thus in Nature a calcium cycle, comparable to the better-known nitrogen cycle. In the latter a seemingly extraneous but all-important factor is the intervention of bacterial action. A corresponding part is played by ultra-violet light on the calcium cycle.

AGRICULTURAL METEOROLOGY.

133. Until 1924, meteorology was included in the syllabus of the chair of physics. On the death of M. Angot this chair was suppressed and replaced by a chair of physics and electrotechnics and by a lectureship of agricultural meteorology.

Syllabus of the course.

(10 Sessions).

Examples of services rendered by meteorology to marine and serial navigation and to agriculture.

Plan of the course: Physics of the air, weather forecasting, climatology of France applied to agriculture.

First section - Physics of the Air.

Constitution and composition of the earth's atmosphere.

Heat

Heat received by the atmosphere and on the surface of the earth; solar heat, seasons, procession of the equinoxes. Variation of the heat received by the soil a function of the season and of latitude.

Distribution of temperatures in the atmosphere. Actinometry, solar constant.

Normal temperature, its variations with the hours of the day, with the seasons and different periods of the year. Influence of the nature of the soil, of the geographical situation and of the meteorological conditions.

Variation of temperature with latitude: annual isotherms at the surface of the earth.

Atmospheric Pressure. - Variation of pressure at a point: diurnal wave, semi-diurnal wave. Influence of the season, atmospheric tides.

Variation of pressure with altitude.

Applications: determination of differences of level, reduation of barometric heights to sea level. Distribution of pressures at the surface of the earth; annual and monthly isobars.

The wind in the atmosphere:

Determination of the direction and force of the wind at the surface and at an altitude, aerological observations. Variation of wind with altitude.

General causes of wind, gradient of pressure.

General circulation of the atmosphere: constant winds.

Seasonal winds, regional winds.

Water Vapour in the Atmosphere. - Humidity; diurnal and annual variation at a point.

Condensation of water vapour: by cooling, by mixing, by radiation. Mechanism of the formation of clouds.

Constitution of mists and clouds. The different cloud forms, their altitude, their thickness.

Fog: distribution of fog at the surface of the earth. Annual isonephs.

Rains or precipitations: amount of precipitation: distribution of rains at the surface of the earth.

Second Section - Rational Weather Forecasting.

The problem of weather forecasting: barometric depressions and cyclones, high pressure areas and anticyclones.

Buys Ballot's Law. Angle of the wind, to the isobars, divergent winds. Relation between wind force and the pressure gradient; normal wind.

The principles of weather forecasting: distribution of weather in a cyclone, relation between the weather and anticyclones. Practical forecasting: preparation of synoptic charts; laws of movement of depressions or high pressure tendencies, force of the wind, direction of wind, earth temperature.

Use

Use of aerological observations for weather forecasting. Law deduced from the aspect of clouds: cloud changes.

Example of the methodical discussion of an isobaric chart.

General order of depressions.

Centres of action in the atmosphere.

Influence of seasons on meteorological phenomena and on the coefficient of probability of forecasts.

Regional forecasts. West and North-West France, South and South-East France, East France.

Forecasts for different periods: short dated, forecasts of yield, Normal period: 24 hr. a period of several days and several weeks. Under what conditions are these different forecasts possible?

Third section. - Climatology of France and its Application to Agriculture.

Practical examples of the use of Climatological Data. - Temperature.

Distribution of temperature in France: diurnal and annual variations. Isotherms.

Influence of temperatures on vegetation: minimum temperatures for germination, leafing, flowering and maturity. Quetelet's tables.

Theory of accumulated temperatures; critical applications.

Soil Temperature. - The struggle against adverse temperature phenomena.

Winter frosts, spring frosts: forecasting, defensive measures.

Winds in France. - Prevailing winds, annual variation in direction and speed.

Local winds in France. Sea breeze, mistral, sirocco.

Effects of wind on agriculture: useful action, harmful action.

Protection against wind.

Water vapour on the soil: dew, hoar frost, rime, glazed frost; circumstances of production. Effects produced.

Rains in France. - Distribution of fog; isonephs in France, diurnal and annual variations. Influence of contour.

Rains: convection, cyclonic and contour rains. Annual rainfall in France, variation with season.

Distribution of rains over the year; rainfall systems; continental, maritime, transition.

Rainfall fraction and monthly rainfall coefficients. Application to the different regions of France,

Agricultural

Agricultural advice.

Place of rain in agriculture: influence on nutrition and evaporation, action on vegetation.

Remedies against excess and deficiency of rains.

Snow: place in agriculture.

Hail: warning signs, influence of geographical situation. Tentative defence. Insurance.

Climates of France.- Classification of climates.

Determining causes of climates: latitude, winds, atmospheric pressure, proximity of large masses of water, ocean currents, contour of the ground, influence of vegetation.

Climatic divisions of France: Armorican (Brittany) region, etc.

Influence of climates on vegetation: distribution of vegetation on the surface of Europe, distribution according to altitude.

Agricultural regions of France. olive, vine, cereals, pastures, forests.

Have the climates varied? Can they vary? Can man change them?

Session of Practical Work (Compulsory). - Taking of meteorological observations and drawing up of a wireless weather report. - Measurement of atmospheric pressure and reduction to sea level at zero.

Measurement of absolute and relative humidity (by the psychrometer).

Determination of fog, of the nature of clouds, of the speed and direction of the wind on the ground.

Drawing up a coded meteorological report.

Session of Practical work (Optional). - Rational weather forecasting. - Preparation of an isobaric chart. Discussion of the chart.

Drawing up of a forecast bulletin.

Remarks on the Sessions in Agricultural Meteorology.

As can be seen from the detailed syllabus above, the lessons on meteorology are slightly changed and they will certainly gain by being less compact.

It should be pointed out, however, that they comprise a minimum of knowledge indispensable for the understanding of essential meteorological phenomena and their application to agriculture. It has been necessary to omit all that concerns

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the various instruments used in making meteorological observations. Optical phenomena and phenomena of ionisation have also been omitted. The theories of the "polar front" and the "lines of current" of Bjerknes and his school have been cut out. Only a few words have been included on forecasting without the synoptic chart and on regional forecasts. Nothing has been said about cycles in meteorology, etc.

Even so, the large amount of material has made it necessary to pass rather rapidly over the applications of climatology to the various farming operations.

For the practical work, a single session allows only of the handling of the principal instruments used at meteorological stations to be demonstrated to the students. A second session is necessary in order to show them how to make a rational weather forecast and to give them an understanding of the services rendered to agriculturists by lectures and by the interpretation of a synoptic chart. This second session has seemed, nevertheless, so indispensable in 1923-24 that its repetition has been assured during the academic year 1924-25.

As soon as circumstances permit, it is desirable in order to give to the course in meteorology the development which it deserves and to augment its usefulness, to increase the number of sessions from ten to fifteen and to provide two sessions of practical work for each student.

134. * The culture of sugar cane, (a plant of tropical origin) in South Louisiana, an area near the climatic limit of production, is necessarily attended by increased climatic hazards. By statistical analysis of the weather and crop records, the importance of the effects of weather fluctuations upon cane yields are demonstrable. Average monthly temperatures from three points and average precipitation from ten stations, with departures from normal, were computed for the sugar region for the period 1890-1924. Yield tables showing acreage of cane, tonnage harvested, sugar produced per acre, sucrose content of the cane and the ratio of sugar to molasses for almost every year from 1888-1924 were also constructed. From an analysis of the data obtained it was possible to compare the relative influence of (a) monthly rainfall departures, (b) monthly temperature departures, and (c) monthly sunshine percentages upon (1) sugar yield per acre (2) the sucrose content of the harvested crop and (3) the ratio of molasses to sugar produced. It was concluded that the more mature cane, produced in a longer growing season and drier ripening season, reflected its quality in improved yields from succeeding crops. Conversely, shortened growing season accompanied by a warm wet summer and an autumn meant a diminished yield from the next crop.

As a test comparisons were made between the rainfall of tropical cane producing regions and that of Louisiana. The tropical regions were uniformly characterized by distinct wet and dry periods and it was found that the best yields were produced in Louisiana in those years or terms of years when rainfall most closely approximated the seasonal type of the tropics with accentuation of wet and dry seasons.

135. *In order to meet the constantly growing demand for an economical and efficient wind power plant, scientists at the College of Agriculture, University of Nebraska, have been experimenting for several years. They have found that a wind velocity of nearly 10 m.p.h. is necessary to charge batteries, the wind wheel being exposed to an elevation of 60 ft. In view of this requirement it is interesting to know how much of the time a 10-mile wind may be expected. What percentage of the time will the wind be too light? How often do these periods of low wind movement occur? What is their average and extreme duration? During what part of the year and the day are they most frequent?

From a study of the Weather Bureau records of wind velocity for the 10 years 1912 to 1921 inclusive it was found that for the year as a whole a velocity of 10 m.p.h. or more for at least 5 hr. of the day occurred on 75 per cent. of the days, and for 5 or more consecutive hours each day on approximately 67 per cent. of the days.

It is not necessary to charge batteries continuously and under average conditions charging for 5hr. every 2 or 3 days would seem sufficient to keep the batteries in good condition. Periods of from 3 to 5 consecutive days without sufficient wind to charge the batteries were not of frequent occurrence but occurred often enough to require careful consideration. They seemed to be more frequent in late summer and early winter and least frequent in spring, with a secondary minimum frequency in autumn. Periods of low wind movement exceeding 5 consecutive days were uncommon, averaging less than 1 each year, and were quite evenly distributed throughout autumn, winter and summer, but did not occur during the spring.

While the data presented may not prove the feasibility of operating electrical generators by wind power, they at least show the possibilities.

136. *1. Rous chicken tumours capable of infecting by cell-free filtrates can be destroyed by B radiation.

2. The dose required is not very different from the dose required to destroy mouse and rat tumours, and is very much less than that required to destroy Rous tumour by means of X rays applied <u>in vitro</u>.

3. Chickens in which tumours have been made to disappear by B. radiation exhibit resistance to subsequent infection.

137. *The American investigators Hess and Steenbock have recently shown that the anti-rachitic vitamin D can be replaced by ultra-violet rays. During the past year in the Animal Breeding Institute of the University of Königsberg the converse was not found to hold true, viz. sunlight was not successfully replaced by food containing all the requisite vitamins. Lambs were kept in the stall all the summer without going into the open: in spite of being fed rations rich in vitamins and excellent in other respects they suffered so badly from rickets that some had to be killed, while the others remained remarkably behindhand in growth.

Other investigations had the object of ascertaining whether the milk of an animal exposed to sunlight but whose feeding was either completely or nearly deficient in vitamins would possess the property of curing or preventing rickets. For the experiments two cows of about 1,000 lb. live weight were used. One of them, in calf, was for over 3 months fed on food very poor in vitamins but was irradiated for the whole of this period. At the end of the period a completely normal calf was born weighing 90 lb.

A non-irradiated control cow received normal food. During the second period 15th May to 30th May both cows received the same food of normal quality. Both cows were kept in the stall and, therefore, had no direct sunlight at all.

Two series of experiments on rats showed (1) that rickets were cured through feeding the milk of the cow which was irradiated but fed foods deficient in vitamins, (2) that by feeding the milk of the irradiated animal as an addition to a rickets-producing diet rickets were prevented.

In the first series of experiments rats were fed on a rickets-producing diet. After 14 days X-rays showed the presence of rickets. The experiment was continued for a further 14 days after which the rickets were very severe.

Thereupon 8 c.c. of milk per head per day from the irradiated cow were fed in addition to the other food. Within a further 14 days the rickets were cured. The whole of the experimental animals re-acted similarly to this treatment.

In the second series of experiments the milk of the irradiated cow was fed in quantities of 3 c.c. and completely prevented the appearance of rickets, while the same quantities of milk from the non-irradiated cow fed on normal food were without effect.

These results afford guidance in the keeping of milch cows especially during winter months. It is quite customary to keep animals in the winter continuously in stalls which are much too dark. Unfortunately too, ultra-violet rays do not penetrate ordinary windowglass. Such a method of keeping animals is wrong. All animals should be let out into the open air for from 1 to 2 hr. every day, in the first

place

place so that the sunlight may result in the production of vitamin-rich milk, and in the second place so that the animals may be healthy.

Mercury vapour quartz lamps for the prevention of rickets are now being recommended in agricultural practice. Many breeding establishments suffer not infrequently from rickets in their breeding bulls. In spite of the high cost of running there is no doubt that the purchase and use of quartz lamps is a paying proposition in such establishments. How far keeping the animals for 1 or 2 hr. every day regularly in the open would dispense with the necessity for the use of artificial irradiation or would limit the need for such irradiation, must be left to be determined by further experiments. The need for the utilisation of direct sunlight in establishments in which milk for children is produced is amply shown.

138. * The well-known American investigator Hess has succeeded in conferring anti-rachitic properties on materials outside the living organisms. He submitted cotton seed oil for 1 hr. to short wave (under 400 Å) rays and showed that the anti-rachitic vitamin D was present in sufficient quantity. Rats fed on this activated oil did not become rachitic, while control animals fed on non-irradiated oil did. Hess had the same success in the irradiation of growing wheat. The results of Hess have been confirmed in Germany by von Gyorgi and Bäumer. It must be remembered that ultra-violet rays are the chemically effective rays which are outside the visible spectrum, and have a wave length of less than 400 Å i.e., less than one 400-millionth part of a millimetre. The best source of ultra-violet light is a quartz mercury vapour lamp; quartz has a high melting point, and does not absorb the ultra-violet rays.

In experiments by the author, a quartz lamp supplied by the firm Hugershoff, in Leipzig, was used. It was sought in the first place to irradiate milk, in order to give it stronger anti-rachitic properties. Investigations by various workers had shown that milk produced in the winter was especially poor in vitamins - not only the fat soluble vitamin A but also of the anti-rachitic vitamin D. Further, the anti-scorbutic vitamin C very susceptible to high temperatures, is also present in only small quantities in winter milk, in much smaller quantities than in milk from cows fed on pasture or green food. According to investigations by Hart of Wisconsin, the anti-beri-beri vitamin B in milk is less dependent on the food. It has further been established that vitamin C is very susceptible to heat. It thus follows that milk must be very carefully handled, especially when it is for feeding children, in order to have the optimum nutritive value and vitamin content. From this point of view it would be best to feed the milk raw, but in this case there is danger from pathogenic germs. For milk for children therefore, it is necessary to increase the quantity of vitamin D (the anti-rachitic and growth production factor) to maintain the content of the susceptible vitamin C and, if possible, also to make the milk sterile. Milk irradiated with a quartz mercury vapour lamp showed a characteristic but unpleasant taste and smell, somewhat resembling cod liver oil, and also ozone. The prevention of ozone-taste proved very difficult. On account of

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the small penetration of short wave rays, it was necessary to expose the milk in a very thin layer to the influence of light. The author had the milk steam of a maximum thickness of 0.5 m.m. at an average distance of 30 cm. from the light, the milk being in a continuous stream. The milk, besides the above-mentioned characteristic taste, also took on a colour, viz., light reddish yellow. This confirmed the assertion of Hart that the natural yellow-coloured foods have a higher content of vitamin D than white-coloured foods. Hart found, thus, that yellow maize and yellow roots possessed more vitamin D than the white varieties. The high content of carrots and tomatoes in the fat soluble vitamin is well known. It was also found that irradiated milk became sour much less quickly than non-irradiated milk. It can, therefore, be assumed that the bacteria are limited in their activity by irradiation. This suggested the question whether pathogenic bacteria could also be destroyed by short wave rays. Courmont and Rogier found that water with a very high content of typhus bacilli was rendered sterile in about a minute, and that pure water was immediately rendered germ free by irradiation; the liquid, however, must apparently be free from colloids It is apparently not possible to render milk sterile easily, as it is a colloid holding medium. Milk containing tubercle bacilli was irradiated for 5 min., 15 min., and 30 min., and inoculated into guinea pigs. The results were positive. The colloid content of milk, therefore, prevents the killing of pathogenic germs. In fact, sterile milk cannot be produced by irradiation, and the indirect method of irradiation of the cow itself must be pursued. Irradiation systematically carried out where no pasture is fed increases the health of the animals. One of the author's cows, suffered from rickets; after 6 weeks the animal lay down and was so thin that it only weighed 748 lbs, the joints were thickened. After 10 days of irradiation the cow stood up, after 15 days the thickening of the joints disappeared, and the appetite increased. The milk yield was raised from 4 litres to 11½ litres, the hair became glossy again and the eyes clear. Before and during irradiation the feeding was the same. The period of irradiation at the beginning was 10 min., increased later to 15 min., to ½ hr., on every third day. There was no appearance of burning during irradiation; the cow appeared to be comfortable. Not only was a complete cure of rickets obtained but the cost of the lamp was very much more than repaid.

139. This paper of some 80 pages is a study of the effect of weather on the crops grown at the experimental station at Gottingen in the 23 years 1900-1922. Correlation coefficients are given showing the effect of various meteorological elements at various stages in the growth of rye, winter wheat, oats, barley, spring wheat, peas, beans and potatoes. The following conclusions are reached with reference to the range of meteorological conditions experienced at the Station:-

1. The correlation coefficient method is a very useful one for establishing the relation between yield and weather.

2. In this method one must proceed on the basis of growth stages of the plants.

3. Definite rules can be found for the effect of weather on yield.

4. Yield is strongly affected by critical meteorological factors during critical periods.

5. The following critical factors and periods were found by this study:

   a. Rye. In the first ten days of the flowering period rainfall should be as low as possible.

   b. Winter Wheat. In the period between the beginning of flowering until 10 days after completion of flowering (25 days in all) rainfall should be as low as possible.

   c. Spring Wheat. In the 20 days after beginning of flowering the rainfall should be as low as possible.

   d. Oats. In the 20 days after appearance above ground the average temperature should be as low as possible.

   e. Barley. In the 20 days after appearance above ground the minimum temperature should be as low as possible.

   f. Potatoes. In the 20 days after beginning of flowering the average temperature should be as low as possible.

   g. Peas. In the period between appearance above ground and beginning of flowering the rainfall should be as low as possible.

   h. Beans. The highest possible rainfall throughout.

6. Sunshine, as a light factor, is unimportant. Sunshine is only a reflection of rain and temperature. Further studies on the point are, however, necessary.

7. Much more importance attaches to early sowing in the case of oats, barley and spring wheat than in the case of peas.

8. The establishment of critical factors and periods and correlation coefficients affords an excellent means of forecasting yields with great certainty long before harvest. In 1924 the yields from the experimental field were forecast in the summer with great accuracy by these means.

9. The rules established by the study were also tested by forecasting on a neighbouring farm

where

where conditions were similar to those at the experimental station; complete agreement was found.

10. The relations between yield and weather can only be investigated in limited areas with the same soil and weather conditions.

11. The optimum rainfall figures correspond closely with the figures of the amounts of water required by the various crops as given by von Seelhorst.

In order to find further relations between yield and weather, a large number of further meteorological factors must be examined, e.g. relative soil moisture, duration and intensity of rainfall, temperature in the sun, relative humidity, etc.

140. The value to the farmer and the tourist of weather forecasting and a knowledge of climatology is discussed, with specific reference to conditions in France and particularly to the climatic controls and centres of meteorological action operative there, such as the low-pressure centre over Iceland and the high-pressure centre over Siberia and eastern Europe, as well as sun-spot frequency.

The information which the meteorologist can now give the farmer regarding future weather (forecast) is considered to be of less value to him than that which is available regarding past weather (climatology). Examples of the relation of temperature to germination and growth of a number of crops are cited.

141. In this abstract of a paper presented at the 1925 meeting of the American Meteorological Society at Kansas City, Mo., it is stated that the ideal climate for the potato "is one in which there is about 14 in. of rainfall and an average temperature of 64°F. for a period of 128 days, which includes dates of 2 weeks before planting until 2 weeks previous to digging. Artificial conditions of irrigated districts must approach the natural closely to produce the best results. The potato districts of Wyoming average 61.6°F. with an average rainfall of 9.62 in. for a period of 138 days, but irrigation is practised in several localities.."

"Temperature conditions for July and May appear to affect yields most. If July was warm and dry the crop was good about 22 per cent of the time, but if cool and wet the crop was normal or greater about 99 per cent of the time; if cool and dry the probability was on a 50-50 basis; only 2 Julys of the 25-year period were both warm and wet, and the crops were less than normal in both seasons. Temperatures for May appear to have an indirect influence through advancing or retarding the season, which in turn either places the focal date of the hot spells of summer, 16th July, within the period of blooming of 'new potatoes", or else delays this period of development until after the focal date, when it is generally cooler and more favourable; an advanced season is accompanied by good crops only 14 per cent of the time, while crops are normal or better 90 per cent. of the time when the season is delayed. Therefore, the average date of planting 10th May should be postponed until the closing days of May".

142. The question of the action of forests on rainfall has been debated by foresters, agriculturists, engineers, and others for a long period, the discussion probably dating back to the time at which scientific forest conservancy was first introduced. In the tropical and sub-tropical parts of the world this is not, however, the point of primary importance. The vital factor for the community at large is the determination of how far the destruction of forests in catchment areas and on the sides of hills and mountains in the drier parts of a country affects, in the first place, the level of the water in the big rivers, a matter of extreme importance when the rivers are utilised for irrigation or power works; secondly, the decrease in the local water supplies and in local precipitations upon which the cultivator is dependent; and, thirdly, erosion and avalanches, and the destruction they cause in the fertile valleys beneath. Sudden floods may also cause enormous damage to railways, towns, and so forth.

History has since shown that the wholesale destruction of forests in Spain, Italy, Sicily, Greece and Macedonia has resulted in a great deterioration of climate over considerable tracts, due to loss of moisture, the sterilisation of the soil, and excessive erosion.

Although now well known, the chief action of the forest may be stated briefly. The great factor in mountainous and hilly country is the maintenance of tree growth on parts of the area. In the case of bare slopes the rain rushes rapidly down, causing erosion, only a fraction percolating into the soil, and is carried rapidly away, giving rise to spates and perhaps to serious floods, since the old channels of these streams or rivers are no longer able to carry the excess water of flood levels. A hot sun bursting out on to the slope after the rain quickly dries up the thin layer of moisture covering it. In the hotter parts of the globe subject to heavy rainstorms or monsoons the rushing water starts gullies which eventually become ravines, all surface soil is rapidly washed away, and in the course of years the hillside is eaten into, rubble and boulders being sent down to cover up valuable lands below. When the area is under trees, a portion of the rain, falling on the crowns, drips slowly down on to the layer of humus beneath and sinks into it. The larger portion, perhaps, falls direct on to the forest floor, where it is gradually absorbed in the soft covering which takes it up as a sponge. The water then percolates slowly downwards, filling up springs and underground reservoirs, and reaches the streams in a retarded manner. The flow in the latter is consequently more even and regulated, as also the amount of water which eventually reaches the rivers. The latter can therefore be more depended upon to maintain a normal level when it is required to utilise them for irrigation or power works. The roots of trees protect the surface by holding up the soil, and thus directly prevent denudation.

143. Studies are reported which showed that when the soil moisture sinks below the so-called inactive supply it becomes entirely unavailable to plant roots. The inactive moisture supply is considered to be about equal to the maximum hygroscopicity of the soil, and is independent of the conditions of transpiration and absorbing surfaces.

The wilting coefficient for plants was found to depend upon the transpiration conditions and to vary from 1.5 to 3 times the maximum hygroscopicity of the soil. It did not vary widely for the different ordinary crops.

It is considered necessary in the physiological judgment of soil moisture to investigate the critical moisture values in all soil strata to which plant roots have access, since the inactive moisture, the wilting coefficient, and the maximum hygroscopicity of soils may vary widely. This is said to be especially true of podsol soils. It is also concluded that for practical purposes the wilting coefficient may be taken as double the hygroscopicity.

144. *In the experiments herein described the writer has studied the effect of environmental factors upon the expression of the resistant quality in cabbage exposed to attacks by the fungus Fusarium conglutinans.

It was found that young seedlings of Wisconsin All Seasons and Commercial All Seasons strains were almost equally susceptible to yellows up to the age of 20 days.

A high percentage of plants of the most resistant varieties became diseased when placed under conditions of low soil moisture and relatively high soil temperature, 27°C. to 33°C. but from 21°C. to 24°C. the temperatures nearest those encountered in the field in the Racine, Wis., cabbage-growing section - the resistant varieties contracted the disease only slightly. No evidence of yellows development was noted at a soil temperature of 15°C. and only a comparatively small percentage developed at 18°C.

Cabbage plants of both resistant and susceptible strains grown in healthy soil at 12°C. to 16°C. before transplantation to diseased soil at a higher temperature (27°C.) proved to be more susceptible to yellows than plants grown at 25°C. to 28°C.

Air temperature affects yellows development independently of soil temperature. Wisconsin Hollander and Commercial Hollander plants were grown in naturally infested soil at soil temperatures of 15°C. 21°C. and 27°C. in each of three greenhouse rooms kept at 14.5°C., 19°C. and 25°C. respectively, for 30 days. At a soil temperature of 27°C. the disease developed most rapidly in the 25°C. chamber and slightly more slowly in the 19°C. and 14.5°C. chambers, but the final percentage of disease was about equal in the three. At a soil temperature of 21°C. the disease developed most rapidly

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in the 25°C. room and less rapidly in the 19°C. room, and the disease was very slight in the 14.5°C. room.

Commercial Hollander plants were grown in diseased soil at soil temperature of 21°C. and at air temperatures of 14°C. and 28°C. Yellows developed much more rapidly, a larger percentage of plants was diseased, and a much greater number of plants was killed by the disease at an air temperature of 28°C. than at an air temperature of 14°C.

A study of field conditions for two years and a limited amount of greenhouse experimentation show that the quantity of rainfall apparently effects the amount of disease independently of soil temperature relations. In the summer of 1922 the soil temperatures at Racine, Wis., averaged somewhat lower than in 1923, but the total precipitation was considerably less in 1922 and the average percentage of disease was considerably higher.

145. Preliminary to the investigations on the varying degree of susceptibility of different potato varieties to late blight (Phytophthora infestans), the influence of the following external factors on the development of the fungus was examined: temperature, atmospheric humidity, intensity of illumination, and age and nutrition condition of the host. The criteria selected for the evaluation of the experimental data were intensity of fructification (i.e. vigour of sporangial development within a given period) and eventual formation of aerial mycelium on the leaves, and rapidity of hyphal growth in the tuber tissues. The only nutrient substrata used in the tests were portions of the natural host of P.infestans, and the inoculation experiments were carried out exclusively with freshly discharged zoospores.

The optimum temperature for fructification and for mycelial development was found to be between 19°C. and 22°C., respectively, the maximum and minimum being 26°C. and 8.7°C. and 27°C. and 4.6°., respectively. For zoospore formation the optimum is between 12°C. and 14°C.

Complete saturation of the air with water vapour being admittedly the most suitable condition for sporangial formation, the experiments relating to this factor were confined to ascertaining the minimum degree of saturation essential for sporangial fructification. It was found that a degree of atmospheric saturation of 73 per cent on the leaves and 64 per cent. on the tubers rendered sporangial development possible. Below these points only vegetative growth occurred. The fact that sporangia developed on the tubers at a lower degree of saturation than on the leaves is regarded as indicating that the nature of the substratum modifies the influence of atmospheric humidity on sporangial development.

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The growth of P. infestans did not appear to be affected by the degree of intensity of illumination.

146. The results of experiments are reported in which rickets in chickens were cured by feeding milk from cows exposed daily for from 15 min. to 30 min. to ultra-violet light, while other chickens getting milk from cows not receiving this treatment tended to become progressively worse.

147. *The weather of the spring months is the most important in hay production in New York State, and no single month is as important as a combination of months. The most important factor is the rainfall from April to June, inclusive, and the second in importance is the May to June temperature. The estimate of yield as computed from weather factors still leaves something to be desired, but averages 47 per cent. closer than the deviation of yield from the average.

148. From observations made during 1922-25 the conclusion is drawn that the first three months of growth are the most influential in determining the yield of roots and sugar, the weather of the month of August furnishing the most reliable basis for predicting the yield of roots and leaves and the sugar content of the roots. It is proposed by frequent weighings and analyses to determine more definitely the behaviour of the plant under varying meteorological conditions.

149. *Seasonal factors, through their influence on the rate of development and maturing of sweet corn, are important in determining the quality of the canned product. In the present experiments the rate of growth, the length of the growing period, the size of the plant and of the ear, the yield of corn, and the rate at which maturity proceeded were modified very materially by variations in the environmental conditions.

The number of days from planting to the time of silking ranged from 55 to 79 for Golden Bantam and from 63 to 92 for Stowell's Evergreen. The principal factor responsible for these variations was temperature. The longest time required to reach the silking stage was in plantings made early in the spring; the shortest time in plantings made in early summer. As the coolness of autumn approached, the time between planting and silking was correspondingly increased.

The number of days from the time of silking

to

to the time most favourable for canning ranged from 20 to 40. Here also the tests indicated that temperature was the principal factor determining the length of the period. As the maturing period passed into the cool part of the autumn, the most favourable age for canning was correspondingly increased.

The toughness of the corn as measured by its resistance to puncture increased continuously throughout the period of its development. Toughness has a very important influence on the quality of the canned material, for as toughness increases the quality of the corn is progressively lowered until it becomes unsuited for table use. Stowell's Evergreen at corresponding ages was somewhat tougher than Golden Bantam.

The yield of cut corn increased rapidly in the corn maturing in mid-summer. In the cool autumn it increased more slowly but for a longer time. The proportion of cut corn to cob and husk continued to increase throughout the entire period of development and maturing of the ears.

The percentage of moisture in the developing grains decreased continuously during the growth and maturing of the ears. It decreased most rapidly during the hot summer days and less rapidly in the late autumn. Stowell's Evergreen was found to be characteristically higher in moisture content than Golden Bantam. Corn in prime canning condition had a moisture content ranging from 25 per cent. to 30 per cent.

The total sugar content of the very young grains was medium to low, increased for a time as development proceeded and then decreased as maturity approached. The rate at which the changes occurred depended primarily on the prevailing temperature. Whenever a change in temperature occurred it affected the development of the ear during that period regardless of the stage of maturity.

The sucrose was low in the early stages of development, increased rapidly for a time, and then decreased slowly until maturity was complete. The changes were also effected by the prevailing temperature, so that in the cool autumn the age at which the highest sugar content occurred was greater than in the early plantings.

The reducing sugars were high in the early stages of development of the corn and decreased steadily as maturity advanced, the rate depending on the temperature.

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The polysaccharides were found to consist of a portion soluble in cold water, probably chiefly dextrin, and a portion insoluble in cold water, which was principally starch. When the corn was in prime canning condition about one-half of the total polysaccharides were water soluble, and environmental conditions did not seem to alter this ratio to any extent. Owing to the slower rate at which maturity progressed, the quantity of polysaccharides was smaller in the corn developing during the late autumn than in corn of the same age developing during the hot season.

Of the seasonal factors concerned with the growing and canning of sweet corn, temperature was found to be the most important as affecting the quality of the canned product. The rainfall had a very marked effect upon the vegetative activities of the plant, but produced no significant effect on the chemical composition of the cut corn or the quality of the canned product. No specific effect of sunshine could be detected in the experimental findings of this study.

Light frost had no significant effect on the composition of the corn or the quality of the canned product. For the first few days after a heavy freeze the canning quality was almost equal to that of the unfrozen corn, but the quality deteriorated rapidly thereafter owing to the discoloration and the activities of micro-organisms.

150. This is an account of an ecological study dealing with (1) periodical phenomena in the life of the olive and at different stages of the growth period, (2) correlation of growth with meteorological conditions to determine optimum conditions of growth, and (3) correlation of temperature and precipitation and physiographic conditions with olive culture. The effect of deficiency or excess of rainfall and temperature at different periods of growth is dealt with in some detail.

151. In correlating the frequency and the area of surface of fires with records of weather for the same days, the author found that in hardwood stands relative humidity is a potent factor. Based on records for the years 1922-1924, a median table in which the area of a fire burning for more than one day was proportioned over the entire period of the fire, gives for humidities of 90 per cent., 80 per cent., 70 per cent., 60 per cent., 50 per cent., and 45 per cent. area figures of 3,5,7,10,15 and 20 respectively. The humidity of the day preceding a fire had an even greater effect.

152. *1. Studies have been made to determine the influence of air temperature, soil temperature and soil moisture, humidity, light and nutrition on the symptoms of potato mosaic.

2. Air temperature was found to be the main and only factor affecting the amount and intensity of symptoms on potato foliage under greenhouse conditions.

3. Experiments conducted in constant air-control chambers indicated that relatively short exposures to air temperatures above that of the critical air temperature (23°C. to 24°C.) were sufficient to mask the symptoms of mosaic. The rate of masking was found to be dependent largely upon the duration of exposure, upon the air temperature to which exposed, and upon the age of the leaves.

4. Differences in air temperature accounted for marked variation in leaf area produced on mosaic plants exposed for the same length of time.

5. Masked mosaic plants subjected to low air temperatures always re-developed characteristic symptoms of mosaic.

6. Symptoms of mosaic on the Triumph variety appeared in the field at a high altitude when air temperatures were favourable, but mottling was not as marked as under low altitude conditions.

7. High soil temperatures may be of importance in masking mosaic plants during the earlier stages of growth, regardless of the amount of moisture present in the soil, or air temperature favourable for the appearance of symptoms.

8. Soil moisture, humidity, light nor variation in these three essential elements for plant growth neither decreased nor intensified the symptoms of mosaic potato plants.

9. Histological studies indicated that masked leaves show marked deviation in structure from healthy leaves.

10. The time and duration of the period of masking varies in different potato-producing regions.

11. Intermittent air temperatures are of fundamental importance in connection with the tuber-index method for testing seed potatoes, in seed potato inspection and certification, and is experimental studies on mosaic.

153. Experiments to show the relation between the water content of different soils, sand, clay and peat, and the yield of different cultivated plants are reported.

Apparently the same plant behaved in the same way toward the soil moisture of different soil types when this was calculated on the basis of available water in relation to available water at full water capacity. On the other hand, different plant species behaved in different ways toward the water content. A satisfactory yield of sugar beet was obtained at a rather low water content, followed in order by wheat, barley, oats and clover. The clover required considerable water in the soil to produce a good yield.

These results are taken to indicate that if the influence of the water content of one soil on a certain species of plant is known, it is possible to calculate the behaviour of the plant in other soil types when the constants for unavailable water and full water capacity are known.

In this connection, data on the water requirements of different plants at different soil moisture points and the water requirements at maximum growth are presented. On the assumption that 50 per cent. of the rain during the summer season is lost by evaporation, the conclusion is drawn that in the agricultural regions of southern Sweden crops obtain from 600 c.m. to 2,500 c.m. of water from March to August, and

that

that in the case of the experimental crops more than 600 c.m. of water are required. This is taken to indicate that in some parts of Sweden irrigation would give good results.

154.* A comparison by the author at the Forest Research Station, near Knysna, S.A., between the rainfall recorded by an ordinary open raingauge and by one bearing a screen of vegetation shows a much higher catch in the screen gauge. In the twelve months June 1925 - May 1926 the control registered 52 in. only, the vegetation - screened, 94 in. For every month except February, 1926, the screened gauge registered the higher catch - the reason for the higher catch by the control in February being that the precipitation took the form of normal and of heavy showers. A classification of rain types for the period shows -

79 per cent. of the rains to have been of fine, misty nature.
13 per cent. normal showers.
8 per cent. heavy downpours.

Detailed readings indicate that the greater catches registered by the vegetation-screened gauge occurred as the result of the fine rains.

The fine rains caused the deposition of large amounts of moisture upon the exposed crowns of the Knysna Forest trees and make the forests dripping wet while the ground immediately beyond their margins is comparatively dry.

The subject of interception loss due to vegetation has been studied by Horton who, working in Albany, N.Y., concludes that rainfall interception represents a loss of rainfall which would otherwise be available to the soil, and shows that the interception loss is greater in forests than in field crops.

The author, using two gauges - the first placed under canopy of high forest, the second set under full exposure - found as follows:-

(1) For the period 1st February, 1923 - 31st January, 1925, the total catches by the gauge under canopy and by the control were 65.98 in. and 85.0 in. respectively; that is, there was an interception loss of about 22.4 per cent.

(2) The total number of days on which 0.01 in. or more was registered, was 58 days less under canopy than in the open.

(3) Interception losses were greater during Nebrelreissen or fine rains, owing to the foliage, branches, and boles taking up so much of the moisture; heavy downpours lowered the interception loss considerably.

Observations are showing that while there is this well-marked interception loss below the trees, within their crowns the actual total catch of moisture is far greater (30 per cent. to 80 per cent.) than at equivalent heights in fully exposed sites.

155. Experiments in lysimeters were arranged in 1925 with Sword Grass, German Weidelgras, Cocksfoot, Meadow Fescue, Timothy, Meadow Foxtail, Oat Grass and Meadow Grass, sown in spring, 1924. The lysimeters were weighed every five days in summer and every ten days in winter, and the quantity of drainage water measured. The yield was distributed over three mowings which were made on 10th June, 6th August and 1st October.

Yields.

Yields.

No. of Lysimeter.	Variety of Grass.	Yield of air-dried hay in dz/ha. I	II	III	Total
1.	Sword Grass	86.9	74.0	20.2	181.1
2.	German Weidelgras	68.2	48.2	22.4	138.8
3.	Cocksfoot	77.9	69.4	28.3	175.6
4.	Meadow Fescue	68.1	65.0	13.3	146.4
5.	Timothy	83.1	26.6	16.9	126.6
6.	Meadow Foxtail	46.8	74.6	27.1	148.5
7.	Oat Grass	65.1	74.3	27.5	166.9
8.	Meadow Grass	46.9	53.0	19.5	119.4

Watering the grass commenced on 1st May and was continued until 13th June with 20 mm. of water every 5 days. The natural rainfall during this period amounted to 62.7 mm., so that 262.7 mm., or an average of 6 mm. per day was supplied. Nevertheless, lysimeters 1, 2, 3, 4 and 8 gave no drainage water during the period, and the rest only small quantities, with the exception of the Meadow Grass. In view of the small drainage, watering was continued from 14th June until 20th August as before.

As regards the water content, the following conclusions may be drawn:- The water content of the soil during the whole vegetation period from April to September varied in the lysimeters between 14.7 per cent. and 19.3 per cent., the lowest were Sword Grass with 14.7 per cent. and Oat Grass with 16 per cent. both of which had the greatest evaporation. In fallow it amounted to 19.7 per cent.

Drainage in the individual lysimeters showed great differences. Despite the copious water supply from 1st April to 30th September of 300.2 mm. rainfall and 400 mm. watering, there drained from:-

Sword Grass	5.7 mm.	= 0.8	per cent.
Oat Grass	8.5 mm.	= 1.2	" "
Cocksfoot	31.5 mm.	= 4.4	" "
Meadow Foxtail	32.2 mm.	= 4.5	" "
Timothy	66.5 mm.	= 9.5	" "
Meadow Fescue	80.2 mm.	=11.4	" "
German Weidelgras	94.5 mm.	=13.6	" "
Meadow Grass	135.3 mm.	=19.3	" "

As a rule, drainage increased with the fall in yield; thus in the lysimeters which gave the highest yield it was lowest, and vice versa.

The total evaporation and therefore the water consumption of grasses during the months from April to September lay between 566 mm. and 744 mm.

The consumption in individual cases was:-

Sword Grass	744.50 mm.	= 99.2	per cent. of available water.
Oat Grass	691.74 mm.	= 98.8	" " " " "
Cocksfoot	685.20 mm.	= 95.6	" " " " "
Meadow Foxtail	678.35 mm.	= 95.5	" " " " "
Timothy	634.66 mm.	= 90.5	" " " " "
Meadow Fescue	624.47 mm.	= 88.6	" " " " "
German Weidelgras ..	604.1 mm.	= 86.4	" " " " "
Meadow Grass	566.41 mm.	= 80.7	" " " " "
Fallow	244.51 mm.	= 81.3	" " " " "

The

The water consumption was very varied during the individual vegetation periods: during the months of May to September it was as follows per day:-

	April mm.	May mm.	June mm.	July mm.	August mm.	September mm.
Sword Grass	2.2	6.5	5.6	5.8	2.7	1.4
Oat Grass	2.6	6.5	3.9	6.5	2.4	1.2
Cocksfoot	2.3	6.4	4.0	5.7	2.6	1.4
Meadow Foxtail	2.1	6.1	4.0	5.9	2.6	1.5
Timothy	2.3	5.8	4.6	4.5	2.4	1.2
Meadow Fescue	2.0	6.2	3.3	5.1	2.5	1.3
German Weidelgras	2.3	6.2	3.2	4.6	2.4	1.0
Meadow Grass	1.8	5.4	3.3	4.8	2.1	1.1
Average	2.20	6.14	3.98	5.35	2.46	1.01

The figures show very clearly how the highest water consumption takes place during the period of the strongest growth, i.e. in May and a period after the first mowing in July, while in August and particularly in September it falls quickly. The daily consumption on an average for the whole vegetation period lay between 3.1 mm. (Meadow Grass) and 4.1 mm. (Sword Grass); the maximum consumption between 8.7 mm. (Timothy) and 11.5 mm. (Sword Grass): the latter occurred like the greatest total consumption in May. In the fallow lysimeter similar investigation gave 1.3 mm. and 5.1 mm.

It follows that the water consumption of grasses is at times considerable and therefore at times considerable supplies of water must be available if the plants are not to suffer from its lack, although it is to be assumed that in varying degrees they are able to sustain dry periods without the yield being appreciably impaired. From the fact that, for exa ple, Sword Grass from June to September and Oat Grass from June to August yielded no drainage water it is to be assumed that they would have been able to consume still larger quantities of water.

The average water consumption of all grasses during the whole vegetation period worked out at 655.7 mm. The fallow lysimeter approached the same water content as those with grass and in the same period evaporated 244.5 mm. The water consumption of plants therefore can be taken at an average of about 411.2 mm. or round about 63 per cent. of the total evaporation. In the individual cases it amounted to:-

Sword Grass	500.0 mm.	= 67	per cent.	or per kg. of matter harvested.	410	kg.water
Oat Grass	463.5 mm.	= 65	"	"	425	" "
Cocksfoot	440.7 mm.	= 64	"	"	392	" "
Meadow Foxtail .	433.9 mm.	= 65	"	"	457	" "
Timothy	390.2 mm.	= 62	"	"	500	" "
Meadow Fescue ..	380.0 mm.	= 61	"	"	426	" "
German Weidelgras	359.6 mm.	= 60	"	"	435	" "
Meadow Grass	321.9 mm.	= 57	"	"	474	" "

156.* (1) The behaviour of the foliage of certain varieties of apple trees when subjected to immersion in water and subsequent exposure to air is described.

(2) A reduction in dry matter and ash constituents is shown to occur under the treatment.

(3) The course of removal of potassium compounds from the leaves is followed for several varieties of apple.

(4) The rate of removal of soluble constituents from leaves is partially dependent on the individual properties of the exposed surfaces and varies considerably with the variety of the tree.

(5) A comparison is drawn between natural conditions in the field and the conditions of experiment.

(6) Results obtained on the variety Cox's Orange Pippin indicate that potassium compounds are leached from the leaves under conditions occurring in the field.

(7) The work of previous investigators on the solubility of potassium compounds in plants is supported by results obtained with apple leaves.

157. An analysis of precipitation and forest fire data recorded for northern Minnesota during the period 1915 to 1923 showed that the fire preventing effectiveness of moderate rainfall is least in summer and greatest in autumn. Spring rains were intermediate, corresponding closely to the average of the entire season.

158. From results of analyses of rain and melted snow during 3 years, the author concludes that on the average the soil received annually 1,186.19 gm. per decare of nitrogen in the form of ammonia and 69 gm. in the form of nitric acid. No relation was established between the quantity of ammonia in the rain water and the temperature of the air. Nitric acid was found in larger amounts in the rain water during summer than in the melted snow of winter, this being attributed to the action of lightning in summer. Dew and frost were found to contain nitrogen compounds, but it was not possible to determine the amount because of the impossibility of collecting sufficient amounts for analysis. Making an allowance for various possible losses it is concluded that the soil actually received somewhat less nitrogen than the average amount given above.

159.* In transpiration, the response of the mesophyll to

ordinary

ordinary external conditions is masked by the action of the stomata. The stomata, however, can be rendered inoperative by the "slitting" method, and so the direct effect of external conditions on water-loss from the mesophyll can be studied.

The large increases in transpiration rate (10 per cent. to 100 per cent.) ascribed by Darwin to the direct effect of light on the mesophyll could not be confirmed.

Electric light of the intensity of diffuse daylight was found to increase the mesophyll water-loss by an amount of the order of 5 per cent. of which about 1 per cent. is a heating effect. A direct action of light on the rate of water-loss from the mesophyll cells has thus been established.

Very feeble light appears to have no appreciable effect upon transpiration, but with increasing intensities the rate of water-loss rises. It soon, however, reaches a maximum. In the case of Ivy this maximum is 7.1 per cent. above the rate of water-loss occurring in the dark, and with Eupatorium adenophorum the corresponding increase is 5.06 per cent.

Marked differences varying from 1.5 per cent. to 9.35 per cent. were observed in the light response of carefully selected cut shoots of E. adenophorum exposed to the same intensity of light.

With intermittent light a factor other than intensity of light comes into play, a gradual increase in the effect being observed with increase of the rate of intermissions from 300 up to 2,000 per min. although the amount of radiation falling on the leaf remains the same. An after-effect of the light which continues into the dark period is thus indicated.

The mesophyll reacts to humidity changes in a way similar to that of a damp inert surface. The transpiration-humidity curve is linear, and obeys the saturation gradient equation at least at the higher humidities investigated.

The leaf temperature in Ivy, E. adenophorum, and Aster sp. in gently moving air, diffuse light and laboratory temperature and humidity is below that of the surrounding air. As humidity or light intensity increase, however, the leaf temperature rises to a higher value, which may be above that of the air.

The water-content of the mesophyll is an important factor in determining the rate of transpiration.

The nature of the light response of the mesophyll is discussed. It is suggested that the most plausible explanation is the effect of light on the permeability of the protoplasm to water.

160. This article discusses briefly the determination of critical periods, relations between weather and crops, and co-efficients of correlation and regression equations.

The author attaches less value to correlation co-efficients as a basis for predicting crop yields than to a method he describes, based on estimates of damage due to unfavourable weather and other causes, involving the factors of the maximum crop possible in a given place, and estimates of the probable damage. The stated advantages of this method are that (1) it is applicable to all crops, (2) it takes account of all factors affecting crop yield, and (3) it gives both yields and losses.

161. * This investigation has shown that an average mean temperature for the month of March in Prince Edward Island has usually been followed by a normal spring and farm crop yields that were very close to the average of many years. A high March temperature and an early spring has been followed by greatly reduced yields, amounting in some cases to less than 90 per cent of all crop averages. The low mean temperature for March on the other hand has been followed by a late spring and greatly increased yields, except in the case of corn, amounting to as much as 5 per cent above the normal of all crop averages. This correlation will be quite valuable in selecting crops to suit the season; the corn crop being practically assured following a high mean temperature in March. Other crops should be used to replace corn in Prince Edward Island when March is cold.

162. Records taken at the Royal Institute of Agriculture at Portici, Italy, upon olive trees growing under different conditions showed that climate in its various phases, heat, light, water, air and electricity, has an important effect on the percentage of aborting flowers. In individual trees of the Ottobrarico and Coccitano varieties, the flowers on the lower branches showed a significantly higher percentage of aborting ovaries than did those on the upper limbs. This phenomenon is deemed by the author to be due in part to the better light conditions in the upper part of the tree. In trees of different ages the percentage of aborting ovaries was lowest in old trees. Observations on trees growing at 3 elevations, namely 0 ft.. 269 ft. and 984 ft. above the sea gave conflicting results. In a very dry year the lowest percentage of abortion was found at sea level, while in a rainy season the results were directly opposite. In conclusion, the author points out that while nutrition and cultural management are exceedingly important in olive production, climatic variations play important rôles.

163. * 1. As an average, a temperature of 15°C. was more nearly optimum for complete germination of wheat than higher temperatures, although there was but little difference between 10°C. and 15°C.

2. High temperatures of 20°C. and 30°C. gave more rapid germination, but lower temperatures of 10°C. and 15°C. gave more nearly complete germination.

3. In general, a temperature of 30°C. made the wheat kernel more susceptible to attack by moulds. This temperature also gave more nearly optimum conditions for mould activity.

4. World's Champion wheat germinated very poorly at 30°C. under ordinary conditions. An increase in germination with increase amounts of water at 30°C. suggested that the water initiated chemical and physical changes making greater germination possible.

5. Wheats from Illinois, as well as those from other states, germinated best at temperatures of 10°C. and 15°C.

6. Wheat showed wide adaptation to varying moisture conditions.

7. The spring wheats tested exhibited the same general reactions to varying temperature and moisture conditions as winter wheats.

8. A moisture content of 50 per cent of saturation gave good results with all wheat varieties studied.

9. The rate of initial germination of wheat at varying temperatures followed, in general, the principle of van't Hoff's law for chemical action.

10. The results of these studies confirmed the conclusion of Coffman, namely, that seed testing laboratories should employ lower temperatures for wheat germination than those now generally used.

164. * While the observations on which this study is based cover a period of 4 spring seasons only, the mass of evidence is sufficiently great to enable these generalisations to be made.

1. The temperature of the dew-point at the time of the frost, which can be correlated with the temperature of the dew point at 4.40 p.m. on the afternoon preceding the frost, is too important a factor to be neglected; any accurate scale of critical temperatures for apples must take it into consideration. The data are mere chaos if the dew-point factor be neglected; when it is considered, the evidence fits nicely into an ordered system. Herein, we believe, lies the reason for the dissatisfaction of the growers with the old scales of critical temperatures, for these scales took no account of the amount of water vapour in the air.

Evidence in this paper shows unmistakably that the dew-point at the time of the frost has a very important bearing on the amount of damage that will be caused by low temperature. When the dew-point is 32°F. when the air temperature reaches 32°F., and the dew-point falls as the temperature falls, severely low minimum temperatures can be endured with but slight damage, whereas the same temperature conditions with a low dew-point will cause very severe damage. Comparision of the frost on the 4th April 1926, in test plot No. 11 with the frost on the 15th April 1924, in test plot No. 7, brings out this point in a forceful manner. On the 4th April 1926, occurred a minimum temperature of 22.9°F. The temperature remained below 32°F. during 9hr. 50 min with a duration of 1hr. 10min. at 23°F. with an evening dew-point of 37°F. On 15th April, 1924, occurred a minimum temperature of 26.8°F. The temperature remained below 32°F. during 3hr. 55min. with a duration of only 20min at 27°F. with an evening dew-point of 23°F. In each case there was observed relatively the same amounts of damage to Winesap in stage 6.

It

It is highly probable that one of the reasons such great damage occurs with low dew-point temperature is to be found in the simple relation that exists between the temperature of the dew-point and the rate at which the air temperature rises following a frost. As a general rule, the lower the dew-point temperature, the faster is the rate of rise in air temperature after sunrise.

2. Many conditions define the point at which damage begins with apples in the different stages of development. These conditions are made up of several different factors, chief among which are (1) the temperature of the dew point, and (2) the duration of temperature at different temperature levels below 32°F. Other factors, too, bear on the amount of damage that will be caused by any damaging temperature conditions, chief among which are (1) the rate of rise in temperature after sunrise, and (2) the vitality of the individual tree. The scale of critical temperatures, therefore, necessarily must be complex, and judgment will be required for its practical application.

3. Different varieties of apples show different degrees of resistance to frost. Furthermore, each variety seems to have a particular stage or stages of development wherein it is particularly susceptible to injury. Thus, for instance, Delicious and Winesap show relatively the same measure of resistance to a given condition in the earlier stages of development, but in later stages Delicious proves to be more tender than Winesap.

165. *Life history studies of the species have been carried on in a series of controlled chambers in which the temperature and humidity have been constant. Interesting data have been accumulated with reference to length of instars, longevity and fecundity as inhibited or stimulated by a prescribed environment, There is a definite response in Myzus persicae Sulz. to changes in temperature and humidity. An increase or decrease in temperature and humidity acts as a stimulus. Increased activity is brought about by rises in temperature and humidity but when temperature near 28°C. and humidity near 85 per cent are reached inhibition occurs. The converse occurs with extreme low ranges.

With an increase in temperature and humidity there is an increase in the rapidity of growth, and a speeding up of the process of reproduction. With these conditions the greatest number of individuals are produced, not only on a daily basis, but also for the life of the individual and the time requirement for the newly-born nymph to reach maturity is materially lessened.

With a diminution of temperature and humidity, reproduction is inhibited and the rapidity of metamorphosis is reduced. Also, reproduction persists for a greater duration of time and the individuals live considerably longer.

It appears from the data that in M. persicae Sulz. the processes of metamorphosis, reproduction and longevity are proportional to temperature and humidity. An increase in reproduction and diminutions in the length of nymphal instars and longevity are correlated with increase in temperature and humidity and the reverse is quite apparent with decreases in these environmental factors. This of course applies only within those ranges of temperature and humidity which are not harmful to the species.

166. Data are given as taken in 1924 and in 1925. High soil temperature plays an important role among the conditions which make the arid early summer a critical period for plants, and the cooling of the soil by the midsummer rains, or by irrigation, is an important factor in stimulating activity under those conditions

167.* 1. Weekly sowings of six varieties of oats made during the seasons of 1924 and 1925 show that low smut infection takes place in very early and very late sowings.

2. High smut infection seems contingent on high temperature and low moisture content of the soil. Soil temperatures of 62°F. to 66°F. seemed to be most favourable for infection. Highest infections were obtained with the soil moisture below 30 per cent. of the water-holding capacity of the soil.

3. Removal of the glumes from oats caused a large increase in the amount of smut infection. This increase was largest in susceptible and moderately susceptible varieties and much smaller in resistant varieties.

4. Comparison of the reaction of resistant Burt and Kanota when the glumes are removed indicates that the former derives part of its freedom from smut from the mechanical protection of its glumes, while the latter has a larger amount of heritable protoplasmic resistance. Thus it seems that some varieties of oats escape infection through the protection of their glumes, while others have protoplasmic resistance.

5. 100 per cent. infection was not obtained even with dehulled seed regardless of the heavy inoculation. This may be due to resistant individual plants in the hulled varieties used.

168.* The time of applying irrigation water is an important factor in spring wheat production. Water applied at "jointing" increases the yield of straw and grain but not the quality of the grain as indicated by bushel weight and weight per 1,000 kernels.

When water is applied at "heading" slightly lower yields of grain and straw are obtained than when water is applied at "jointing". But the quality of grain is materially improved as indicated by bushel weight and weight per 1,000 kernels.

Irrigation as late as "blossoming" and "filling" has very little effect on yields of grain or straw, but has a marked effect on grain quality as indicated by weight per measured bushel.

Late irrigations at "heading", "blossoming" and "filling" have a residual effect on the following crop.

Early irrigations at "germination" and "tillering" increase the straw yield to a greater extent than the grain yield but produce a grain of poor quality.

Irrigations of small amounts (1 in.) distributed through the growing season gives the best results but are impracticable.

Soil moisture experiments carried out in potometers did not agree with similar experiments carried out under field conditions.

169. Reviewing the results of a study of conditions in this region of the Union of Socialist Soviet Republics, it is stated that as a whole the soils are naturally fertile and that the size of the crops is determined by the distribution of the scanty rainfall, which averages less than 16in. annually. That is, while poor crops generally occur in years of deficient total rainfall, there have been instances of abundant crops in years of scanty but well distributed rainfall. "If it were possible to take advantage of all the natural factors which go to make up the local climate - especially the snowfall in winter - there would be enough moisture, given also modern and rational methods of agriculture, to insure a regular succession of crops. .... The problem, therefore, appears to be to adapt agriculture to the particular nature of the climate".

The main crop, summer wheat, suffers especially from deficient rainfall in May and June. Rye is less affected by drought at this time. The more extensive culture of this crop and of other crops such as corn, millet, sorgo, beets, and sunflowers, more resistant to prolonged drought, is suggested. Other ways in which the situation may be improved are pointed out.

170. In this abstract of a paper presented at the Washington meeting of the American Meteorological Society, 1926, a summary is given of a study made on an area of about 4,500 sq. miles in Minnesota, from which the author draws the conclusion that, "omitting the influence of other possible factors, there is a notable tendency for forest fires to increase in number with a decrease in the relative humidity. The relationship is most marked in the late spring and early autumn. In both of these seasons the danger is most excessive with relative humidity below 30 per cent., though the danger may be considered imminent with any condition below 50 per cent. Above that value the fire hazard decreases about in proportion to the increase in relative humidity".

171. These experiments were undertaken to furnish further information bearing upon statements or deductions in papers previously published.

Under continuous exclusively electrical illumination (voltage 110, wattage 700), castor oil bean completed its life history from seed to seed and produced vigorous plants from seeds ripened under electric light. Flowers developed their natural colours under the same conditions. Plants of wheat buckwheat, and soy bean under daylight alone grew better than did those under daylight with electric illumination at night; though hemp, wax bean, and sunflower showed a slight increase ascribed to nightly illumination. Under the additional illumination at night, earlier flowering occurred in wheat and sunflower and later flowering in hemp.

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As regards height, flowering time, and weight, wheat, flax, hemp, buckwheat, white mustard, soy bean, castor oil bean, and sunflower grown both in the greenhouse and in the open gave as satisfactory results under 2 hour exposure at mid-day as under 3 hour exposure during the morning or afternoon.

Greenhouse experiments with Indian corn, flax, hemp, castor oil bean, buckwheat, white mustard, soy bean and sunflower at different times of the year showed as good a growth under an average exposure to daylight for 568 hr. 40 min. at a mean temperature of 60.8°F. as with an average exposure to light of 499 hr. 53 min. at a mean temperature of 68.2°F. Experiments with wheat, buckwheat, white mustard, and flax showed as vigorous growth under a glass screen as did that of a corresponding set in the open.

The conclusion is drawn that experiments on the relation of plants to light, to be of value, must take into account not only the duration of light, but also measurements of its intensity, as well as records of the temperature throughout the experiment.

172. Both winter wheat and winter rye require a longer growing season than spring varieties of the same species. The growing season is not sufficiently long in the latitude of Ottawa for the heading out of these varieties if sown in the open in spring. In this respect their behaviour resembles that of winter annuals or biennials. "Both light and heat determine the time of heading out of the two species here discussed, both these climatic factors being of equal importance and, to a certain extent, interchangeable".

173. In 1922, in pursuance of the work previously noted, further experiments were carried on at Ottawa with tomato, soy bean, hemp nettle (Galeopsis tetrahit), and shamrock (Trifolium dubium). The average period of daylight, naturally about 15 hr., was reduced to about 12 hr., between 2nd May and 12th June, but the period of darkening was not the same for all plants.

Tomato plants were affected but little, if at all. Soy bean plants flowered earlier in correspondence with the shortened daylight period. Hemp nettle plants followed later for darkening, but grew taller. Shamrock was delayed about 11 days by being darkened as above noted.

174. Studies are outlined as carried out with dwarf nasturtium, tomato, and pepper, as affected by different lengths of the daylight period. It is thought probable that the differences in the relative length of day and night may influence the form of plant development by affecting the nitrogen-carbohydrates ration.

175. In testing the effect of light on growth, three lots of 100 week-old chicks were placed in brooders with access to direct sunlight, sunlight through window glass, and sunlight through celo-glass, respectively. All lots received a basal mash of yellow corn, wheat middlings, meat scrap, raw bone meal, common salt, and skim milk. The chicks receiving direct sunlight or sunlight through the celo-glass made normal growth throughout the 10 weeks of the experiment, but severe leg weakness developed at the 5th week in the lot having access only to sunlight through the window glass.

B. The effect of Light.

176. (1) Direct sunlight has a strongly germicidal effect on the virus, as is shown by the following experiment.

Samples of dried virus (known to be still infective) were exposed for 1 hr. (a) to direct sunlight (noon, in August); (b) in the shade but exposed to the sky. On subsequent inoculation sample (b) alone proved infective.

(2) Even winter light, transmitted through glass, greatly shortened the period of survival.

In two experiments on virus spread on glass slides and allowed to dry slowly in the air, the samples left in front of a window were inactive after two days, while those kept in a dark cupboard were infective up to a week.

Corresponding results were obtained when the virus was allowed to remain on hay. In the light, the virus was dead in from 2 weeks to 3 weeks, while in the dark the same virus has remained alive for 4 weeks, and this does not represent the end point of survival.

177. The writer has made use of data furnished by 6,200 analyses made during 5 years in sugar factories in Czecho-Slovakia and has correlated the analytical results with the rainfall conditions. It is observed that the sugar content shows its maximum increase after a dry week preceded by a wet one (20 mm.); this increase was on the average 0.80 per cent. and in one year amounted to 1.19 per cent. When a dry week was preceded by another dry week, the increase was 0.75 per cent. With continuous rain, the gain in sugar content is reduced with a certain regularity so that, after a rainfall of 27 mm. the sugar content remains as it was at the end of the first week and is reduced below this limit after still heavier rain. There may be a decrease in the sugar content also with a rainfall less than 27 mm., when the beet has a scanty sugar content and the leaves have withered. The decrease in sugar content caused by abundant rain averaged on the five years 11 per cent. with 35 mm. of rain; in a dry year (1921) it amounted to 1.12 per cent. The sugar content is more stable, that is it resists the decrease better when the root and the leaves are well-developed and fresh. Vice versa the more the beet is dried up, the more easily the sugar content decreases after rain, in consequence of the weakening of assimilation in rainy weather. As regards the rate of growth, it is observed that this varies in direct proportion to the rainfall of the same week and of the previous week. The smallest weekly increase (20.7 g.) was observed in the average of the 5 years during a dry week preceded by another dry week. With continuously increasing rain, the rate of increase in weight of the root becomes quicker, though it slows down again afterwards. The greatest weekly increase (38.3 g.) was observed in sunny weather after a heavy rainfall of 37 mm., when, therefore, the beet had sufficient moisture. The greatest elaboration of sugar in the root took place in a dry week preceded by a wet one. The best conditions for the production of sugar exist when, after a rainy period, the weather becomes fine; in such a case the average weekly increase was 7.62 g. On the other hand during a rainy week the production of sugar fell in such a degree that during a rainfall of 35 mm. the gain in sugar was only 4.89 g. or 64 per cent. of the maximum production. In the same conditions the elaboration of sugar is smaller when the leaves are less developed.

178. *1. Experiments are described showing that it is possible to conduct laboratory experiments on micro-organisms in stored soil, provided that the surface of the soil is large in relation to its volume.

2. Experiments on the influence of moisture on the soil protozoa show that active forms are found in soils containing a very low percentage of water.

3. The flagellate Cercomonas crassicauda was found to excyst and reproduce in air-dried soil brought to 1/6th of the water-holding capacity. The bacteria also in this experiment nearly doubled their numbers in 24 hr.

4. Four common soil protozoa were found to behave normally in soil of ½ and ⅓rd o the water-holding capacity, which previously had been air-dried and then brought to the desired water content.

5. Field soils having water contents of 6 per cent. in one case and 4 per cent. in another corroborated the laboratory experiments. In all of these samples active Cercomonas were found, other protozoa being present only in the form of cysts.

179. * It was found that mean temperatures of 62°F. or more, combined with mean relative humidities of 53 per cent. or less, occurring when the forest, duff and branch wood have already dried out to less than 10 per cent. moisture content, implies a fuel condition conducive to very rapid spread of fire. Such conditions evidently warrant special preparedness in the future. It is further apparent that the big runs of a fire, under the above conditions, are influenced chiefly by wind direction and velocity; secondly, by small changes in relative humidity; and least of all by minor temperature changes. Forecasts of a 24-hour average wind velocity of 7 m.p.h. should be recognised as implying much greater danger than forecasts of an average velocity of 4.8 or 5 m.p.h. As soon as possible the predictions of wind velocity should be refined to apply only to the daylight hours, and preferably to distinguish the afternoon hours. Indications for the occurrence of average maximum, minimum and mean temperatures and humidities, such as those shown for the seven bad days of the Quartz Creek fire, likewise should be met with special preparedness.

The accuracy in later application of all of these findings is contingent upon similar conditions of fuels, topography, and fire suppression technique, all of which are admittedly important factors not considered in detail by the present study.

Another fact, of importance to all students of fire behaviour, is the need of rather elaborate meteorological equipment which will provide graphic records of the weather elements. It should be obvious that irregular or infrequent measurements of temperature, humidity, and wind could not have been used in this study as easily as the continuous records. As large fires close to well equipped weather stations are not of common occurrence, it is altogether probable that special instruments must be developed which can be transported to the vicinity of large fires if much work similar to the present is to be conducted.

Clearly, an investigation of a single fire provides only a small fraction of all the evidence that must be accumulated before thoroughly dependable conclusions can be drawn. Other fires, under similar conditions of temperature, humidity and wind, might exhibit entirely different behaviour if the fuels, the topography, or the tactics of suppression differed materially. Several of these investigations must be made in each distinct timber type under different weather conditions before the major variations of fire behaviour can be accurately related to the behaviour of the weather.

180. * After the fall of the new litter a fire hazard can be created through the agency of sun, wind and low relative humidity on south exposures in a single day following a heavy precipitation.

On north exposures during the autumn season, due to the small angle of insolation and shade cast even by hardwood crowns, no material hazard can be created in one day.

Wind is necessary for rapid drying, especially on north exposures.

Leaves absorb more than their dry weight of water and absorb moisture from moist air without the agency of rain, dew or frost. The moisture content of litter is thus affected by night humidities.

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The period of active drying during the autumn season of 1925 was limited to 6 or 7 hr. during mid-day even on the more hazardous days. High relative humidity was common throughout all nights after the leaf crop came down.

Low moisture content can be estimated by a breaking test.

The conclusions from the autumn season of 1925, as regards drying rate on south slopes, were generally verified in the spring season, although lower moisture percentages were found.

Conditions of wind, sunshine, and relative humidity favourable to forest fire are the regular aftermath of the passage of a storm, and can be forecast with more certainty than precipitation.

Unusual hazard is caused by continuation of high pressure over or west of the Appalachian region, or by the passing of a storm without precipitation in the region.

181. The action of light on plants has had a perennial interest for plant physiologists, and recently the subject has received some concentrated attention. Ferdinand Hercik (Publications de la Faculté des Sciences de l'Université Masaryk, No. 74, 1926) has tried to correlate the action of light and the surface tension of the expressed sap of his plants. He finds that the sap of normally grown seedlings of Lupinus, Sinapis, and Pisum has a greater surface tension than sap from stems of etiolated seedlings. On the other hand, sap from leaves of normally grown seedlings, has a smaller surface tension than sap from leaves of etiolated seedlings. Now, etiolated plants have usually greater stem growth and less leaf growth than normal plants, and the author correlates the greater surface tension with less growth and the smaller surface tension with greater growth. If, however, seedlings have the same length, then the surface tension of their respective saps is the same irrespective of the conditions under which they have been grown. The author has not traced the causal chain between the surface tension of the sap and the actual phenomena of growth.

In a series of papers in the New Phytologist (vol. 24, 5, and vol. 25, 3 and 4), Prof. J.H. Priestley deals with the problem from a slightly differant view-point and advances some tentative explanations of his results. In the case of the broad bean (Vicia Fabe) he was able to destroy some of the more marked etiolation phenomena by only very brief exposure to light - 2 min. in every 24 hr. He points out that any change produced on etiolated plants by the action of light must be initiated, not by the effects of photosynthetic products, but by the photocatalytic effect of light upon the products of metabolism. For example, cells from the cortical region of an etiolated broad bean tip are incapable of being plasmolysed in a 17 per cent. cane-sugar solution, but, after exposure to artificial light for 1 hr. on two successive days, are plasmolysed readily. The author considers that the photochemical action of light releases protein and fatty substances from the developing walls of the cells intervening between the central cylinder and meristem: and these walls,

now

now consisting of purer cellulose, readily permit of the transfer of the nutrient sap from the central cylinder, with an ensuing more diffuse and more superficial development of merismatic tissue. In this way growth, which in the etiolated plant is confined to tips of stems, becomes redistributed.

The phototropic curvature of grass and cereal coleoptiles, the subject of much experimentation, is explained by Prof. Priestley on the basis of the foregoing hypothesis. Thus the side of the coleoptile exposed to the light becomes in consequence more permeable, with greater guttation through the apical hydathode from the vein nearer the light. The cells of the lighted side will therefore extend in length less than those of the darkened side, producing a curvature towards the light.

Following still another line of attack, Prof. Y. Yoshii has experimented on the influence of the relative length of day and night on plants (Science Reports of the Tohoku Imperial University, 4th series, vol. 2, 2). His results, in the main, confirm and extend the work of Garner and Allard in grouping plants into two categories, long and short day plants, according to the length of daily illumination necessary for the production of flowers (Jour. Agric. Res. 18, p.553, and 23, p.871). The evidence adduced leads to the conclusion that there is probably another group of plants which are nearly or entirely indifferent to photoperiods, but affected by other factors as to time of flowering. The author finds that the optimum photoperiod for reproduction does not result in maximum vegetative growth, and that closely related plants, sometimes even varieties of the same plant, may behave quite differently as regards photoperiods: for example, the late variety of rice plant is a short day plant, while the early variety is indifferent to regulation of light period. This seems to suggest that some other factors besides those concerned in photosynthesis are involved. If the photoperiod is the key to the distinction between spring and winter varieties of wheat, then researches along this particular line may have some application in the practical field of crop production.

182. The relation of weather conditions in this region of Assam to the growth and quality of tea is discussed, attention being called especially to humidity as the controlling factor in the growth of the indigenous tea bush. The Assam tea plant "is constructed to live in a hot, humid climate and its leaves are designed so that they are able to transpire freely. The leaves of China bushes are slightly differently made from those of Assam and Burma bushes, and the China jat is able to withstand the drought and cold better than the other varieties".

183. Studies of the effect of sunlight and darkness on the rice flowers gave indications that while blooming was noticeably retarded in darkness, the number of opening flowers was not reduced significantly. However, dehiscence of anthers, pollen shedding, and percentage of fertilisation were not interfered with. The author observed that orange light, followed by yellow, accelerated blooming most, and that the process was also speeded by electrical illumination.

184. A review of literature relating to potato yields is said to have shown that the optimum temperature for tuber yield is about 17°C. and that yields decrease rapidly with an increase of temperature.

The author investigated the effect of a range of temperatures above the optimum by growing potato plants in thermoregulated chambers set to operate at 20°C., 23°C., 26°C. and 29°C. The plants showed conspicuous responses in the leaves and in the tubers, both decreasing in size with increase in temperature. At 29°C. no tubers formed. The maximum temperature for tuber growth under the conditions of the author's experiments was between 26°C and 29°C. Respiration during the night in the above-ground part of the plant increased with temperature. The carbohydrate content of leaves and stems, sampled at both sunset and sunrise, was not appreciably affected by this range of temperature. Reduction in the carbohydrate available for translocation which resulted from the increased respiration at the higher temperatures, roughly corresponded to reduction in tuber growth. Thus the rate of tuber growth appeared to be a function of the available carbohydrate.

From the data of his experiments, as well as evidence from the literature, the author suggests that deficiency of carbohydrate arising from excessive respiration may be very generally the limiting factor in plant growth at temperatures above the optimum.

185. * From 36 experiments with 12 Rhode Island Red hens, involving 137 determinations of the carbon dioxide production during fact and quiescence at different temperatures, it was found that the average critical temperature was 62°F. This value applies to winter-feathered birds in an atmosphere of low humidity and in an air current of approximately 3 litres per min. Some of the individual birds appeared to exhibit distinct differences in their reaction to changes in environmental temperature.

It is shown that Newton's law of cooling bodies may apply to animals at environmental temperatures below the critical. The practical significance of this conclusion is discussed and illustrated.

186. In studying the effect of temperature on the fat percentage of milk the percentage of fat of the milk of the Missouri Experimental Station herd was determined for 258 days and compared with the average daily temperature when the cows were in and out of doors. With decreases in the average temperature from 86.5°F to 49.7°F. the fat percentage gradually increased from 3.171 per cent. to 3.505 per cent., but there was a decrease to 3.463 per cent. at 40.1°F. which was unexplainable.

In another experiment two Jersey cows were kept at constant temperatures of approximately 30°F., 40°F., 50°F., 60°F., 70°F., 80°F. and 90°F. until the fat percentage of the milk became relatively constant. The periods varied in length from 4 days to 8 days. In each of the tests the fat percentage was distinctly different on the 1st day.

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The physiology of temperature relation in animals is discussed, and it is pointed out from these results that the lowest fat test occurs between 70°F. and 90°F., while variations either way increase the fat percentage, probably due to increased metabolism. Between 70°F. and 30°F. the fat percentage increases approximately 0.2 per cent. for each 10°F. reduction in temperature.

187. * Experiments conducted in the greenhouse to determine the relationship between the temperature of the soil and the infection of sweet potatoes by the stem-rot organisms, Fusarium hyperoxysporum and F. batatatis, showed that the optimum temperature for infection is about 30°C. and the maximum about 35°C. The minimum could only be approximated, since infection occurred at a temperature as low as that at which the plant would grow.

The influence of soil moisture on infection was more difficult to determine. Infection was found, however, to occur over a wide range of soil humidity. At 28 per cent. and 75 per cent. of the water-holding capacity of the soil 94 per cent. and 100 per cent. respectively, of the plants became diseased. Infection also took place in a soil containing only enough moisture to support plant growth.

Healthy plants set in infested soil may become diseased. Wounding is not necessary to infection but increases it. A small percentage of sprouts from healthy potatoes dipped in a spore suspension of the causal organisms became infected. The percentage of infection, however, was greatly increased when the sprouts were pulled from the mother potato, both in those that were pulled and in those that remained.

188. Data from experiments at the Iowa Experiment Station on wind-driven electric light plants are briefly presented.

It was found that in most respects the airplane propeller wheel is apparently an improvement over the old type of windmil wheel, although the output of current, judging by three months' observation, was somewhat less. The airplane wheel began to send current into the batteries at a wind velocity of about 10m.p.h. The current increased rapidly as the wind velocity increased from 15 m.p.h. to 20 m.p.h. Wind velocities above 25 m.p.h. brought little increase in current, because the wheel did not remain facing the wind. This is taken to indicate that the propeller may be somewhat more efficient in high winds than the old type wheel, but it is much less efficient in low winds, since it can not utilize a velocity below 10 m.p.h.

189. The results of studies conducted at the Oregon Experiment Station are reported graphically. The conclusion

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is drawn that lighting intelligently applied has the effect of smoothing out the egg production curve, transferring enough eggs from the low price seasons to those of high price to pay all costs and yield a good profit.

190. Two lots of day-old White Leghorn chicks, 14 in each lot, were fed identical rations of 90 per cent. white corn chop and 10 per cent. tankage supplemented with 5 cc. of fresh whole milk as the sole source of vitamin A. The milk fed to one lot was untreated and the other irradiated in shallow pans. All of the chicks were irradiated for 15 min. daily.

At the end of 7 weeks all but 1 of the chicks receiving the irradiated milk had died as against only 2 of the lot receiving the non-irradiated milk. 2 of the chicks which died in the first lot showed well advanced stages of ophthalmia. Other lesions noted were enlargement of the kidneys, with deposits of urates in the tubules, and similar deposits in the pericardial sac, over the pericardium and covering the liver and intestines. The results are thought to point to a definite destruction of vitamin A through irradiation, and to indicate that while the irradiation of milk increases its nutritive value for infant feeding through increasing its content of vitamin D it at the same time decreases its value as a source of Vitamin A.

191. * During the first half of the season, when rainfall was abundant, changes in productivity appeared to be controlled primarily by the prevailing temperatures, though this effect only became distinctly traceable towards the end of May 1926. Distinct indications were obtained, especially during the early part of the season, of a lag between the incidence of changes of atmospheric temperature and their observed effects on productivity, manifestly owing to the slowness with which a wet clay soil takes up heat. Quite the contrary effect was noted in the early part of the 1925 season during the investigation of the seasonal productivity of the sandy pasture. In this case, the response to temperature changes was much more prompt, a rise in the mean weekly temperature being reflected in an increased yield during the same week.

Although the soil conditions in the present investigation were such as to enable the pasture to withstand the effects of short spells of dry weather, yet from the end of July almost to the end of September, a period of fairly dry weather interrupted by occasional days of heavy rain, a correlation was traceable between rainfall and productivity similar to that which was noted during the droughty mid-season of 1925 on the sandy pasture. Over this period, it was observed that a rise or decrease in the rainfall during any one week led to a rise or fall in the yield during the succeeding week.

192. That the physical factors of the environment are often of considerable and in some cases of paramount importance in the inception and spread of disease in plants, plant pathologists and growers of plants know well. For instance, in the absence of certain conditions of atmospheric moisture and temperature, even in the presence of the respective parasites, the "damping off" disease of seedlings, due to Pythium, does not occur; Botrytis does little or no harm in the glasshouse; potato blight may not appear at all, or, if it does, may not become epidemic; celery leaf spot remains practically harmless; beans remain free from Chocolate Spot disease, and so on. Briton-Jones has recently brought forward evidence to show that the Die-back of fruit trees is probably the result of preliminary enfeeblement due either to excessive or to insufficient soil moisture and followed by weak parasites, such as Diaporthe and Cytospora, rather than the consequence of primary virulent parasitism.

Again, physical climatic factors - temperature for instance-sometimes play a decisive part in determining whether a specific disease may or may not prevail in a particular region. The spores of Urocystis Cepulae, the fungus which causes Onion Smut, do not germinate readily above 25°C. and not at all above 29°C. Hence this disease is of little or no importance in hot climates, and is confined to cooler ones. Species of Fusarium and Verticillium which cause wilts of potatoes, tomatoes, flax, etc., differ in their temperature relations. Thus, flax wilt, due to F. Lini is a very serious disease in parts of the United States of America. In the north of Ireland, however, although the fungus is present there, the disease is practically negligible, owing to the relatively cooler summers. Verticillium wilt of the potato is a disease of relatively cool climates and is met with to some extent in this country, whereas the Fusarium wilt, depending on a higher temperature, is, so far as I am aware, unknown in this country, although it occurs in Central Europe and in the warmer parts of America.

Climatic and weather conditions cannot yet, of course, be regulated by man, although attempts to modify their influence have not been entirely wanting. When, however, plants are grown under glass it is possible, to a considerable extent, to control soil and atmospheric temperature, and humidity as well as light intensity; and the most successful grower is he who can so control these conditions as to avoid disease and get a maximum crop. Here the scope for pathological research is wide, because there is still a great lack of exact scientific knowledge as to the precise conditions which favour or impede the onset of the various diseases of glasshouse crops.

193. * The literature on the general subject of freezing and survival both in plants and in animals is briefly reviewed and a bibliography given. Insects representing three ecological groups were chosen for this study viz.- 1, the oak borers exposed to temperature extremes normally; 2, stored-products insects, representing supposedly a tropical or sub-tropical group; and 3, aquatic insects, never exposed to temperatures lower than 0°C. Determinations of the freezing and

under-cooling

under-cooling points were made during the yearly cycle. Both 2 and 3 showed no periodicity in freezing or under-cooling. The oak borers showed marked periodicity. The freezing-point varies directly with the moisture content. Cold-hardiness was produced experimentally by exposure of insects to low temperatures and also by dehydration. Loss of cold-hardiness was produced experimentally by combinations of high temperature, food and high relative humidity. The freezing point ordinarily found corresponds with that of the blood. Repeated freezings of the same insect or tissue showed no hysteresis. There exists in certain insects a secondary freezing-point below that ordinarily found. Oak borers in summer conditions die at the first freezing-point; in fully hardened condition they die at the secondary freezing-point.

194. A species of Eurytoma is a valuable parasite of Harmolita tritici, Fitch, which is very destructive to wheat in certain sections east of the Mississippi. Most of the larvae of the host pupate in early autumn and hibernate as pupae, the rest in early spring. Adults emerge in May and lay their eggs just above the 2nd or 3rd joint in the wheat, the young larvae feeding in the stem. There is only one generation a year. The eggs hatch in about 10 days, and the larvae mature in about 3 weeks. Males occur normally, but the species will breed parthenogenetically.

The life-history of the parasite is practically the same as that of the host, but it usually emerges earlier. The author, therefore, carried out experiments, which are discussed in some detail, to determine the best means of keeping the adults alive and in good condition until their host should be available. It is now known on what they feed in the field, probably on nectar of flowers, but all efforts to keep them alive in as near normal conditions as possible proved unsuccessful. Keeping them, however, in a dormant condition in a damp cellar at a temperature of 50°F. in absolute darkness seemed to meet all requirements.

195. A summary is given of contributions of the Wisconsin Station on the relation of soil temperature to plant diseases, most of the work being carried on at the Plant Pathology Laboratory of the Station between 1916 and 1926. The data have been brought together in order that there may be given a unity of conception and method of the work on the effect of soil temperature on host plants and parasites and of development of diseases.

196. * The pumping plant from which the data presented in this paper were obtained was installed at Kearney Park in the San Joaquin Valley of California for the purpose of lowering the water-table and providing drainage.

Effective drainage can be obtained for a distance of more than 1,000 ft. from the pump. (The author has shown in a previous paper (1917) that pumping from shallow surface wells or sumps does not affect the water-table to an appreciable extent beyond a distance of 100 ft.).

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In order to maintain a constant depth of water-table, it is necessary to keep the pump in continuous operation during the pumping season.

There is no indication that this pump has had any permanent effect on the amount of water available for pumping. Undoubtedly, however, a large number of pumps operated continuously would permanently lower the water-table, even though there was no diminution in the amount of water supplying the underground reservoirs.

There is a rapid movement of water through the water-bearing sands and gravels of the region, as evidenced by the rapid recovery of the water-table to normal when the pump is stopped.

For increased effectiveness in lowering the water-table and thereby providing drainage, and in supplying water for irrigation, it is likely that pumps of larger capacity than the one used may be installed without either creating an uneconomical lift or bringing about a significant diminution of the water supply.

197. These experiments are claimed to have enabled the authors, by a study of the isolated action of each of the different meteorological factors, to ascertain the part played by each factor as influencing the opening and closing of flowers.

198. The study reported on is concerned with the reactions of two lines of barley and 7 of oats to culture under the varied environmental conditions of 6 localities in Norway, as shown by germination, production, length and diameter of culms, tillering and ripening.

199. Investigation at the Minnesota Experiment Station demonstrated that the viability of red clover seeds with a moisture content of less than 15 per cent. of the dry weight is not affected by temperatures as low as -48°C. for short periods, whereas in seeds with high moisture content germination is greatly impaired by low temperatures, declining very rapidly in seeds containing above 25 per cent. to 30 per cent. of moisture. Plants of the same clover variety varied with age in respect to killing temperatures susceptibility to injury being most pronounced when about 3 weeks old or at the time of the formation of the 1st pair of permanent leaves. Considerable difference among varieties was observed in ability to withstand low temperature. European or southern varieties generally proved less resistant than those grown in northern areas of the United States, this variation existing both in seedlings and mature plants.

200. Spinach produces starchy seeds with thin seed-coats, which remain enclosed in the fibrous ovary until germination. At ordinary room temperatures in ventilated chambers, a certain percentage of the viable seeds fail to germinate. In samples of ordinary strength, practically complete germination of vital seeds results from keeping the germination chamber packed in ice during the test. The same result is obtained by removing a part of the pericarp, by germinating uninjured fruits in an atmosphere of pure oxygen, or by subjecting them to a greatly reduced air-pressure for a short time twice daily during the germination period, thus producing a change of air within the pericarp.

During the progress of the test, a gradual rise in hydrogen-ion concentration, not due to carbon dioxide accumulation, takes place in the embryos of living but still ungerminated seeds. At the low temperature or with increased facility of oxygen supply, this concentration does not, before the end of the test, reach the point it has attained at the time at which germination stops in air at room temperature. It is believed that the failure of some seeds to germinate under the latter condition is due to the production of deleterious organic compounds, as in fermentation or in muscular fatigue, the oxygen supply being too slow to complete the rapid oxidational changes taking place.

Other examples from the plant kingdom are cited, where structural characters may be instrumental in affecting the ability to withstand comparatively high temperatures.

201.* Investigations at the University College of North Wales, Bangor, in the early summer of 1926 into the effects of exposure to raised temperatures on the larvae of various species of mosquito showed that:-

1. Anopheles bifurcatus. Below a temperature of 31°C. the larvae do not seem to be affected by heat. Between this temperature and 36°C. a varying number did not survive an exposure of 5 min. Temperatures of 37°C. and above killed all the larvae. An exposure of 1 hr. to a temperature of 35°C. resulted in all the larvae being killed.

2. Aedes detritus. Below a temperature of 37°C. the larvae are not affected; at temperatures of 44°C. and upwards all become inert, and none revives. Larvae of this species all died when exposed to a temperature of 35°C. for 1 hr.

3. Theobaldia annulata. Larvae of this species are unaffected by temperatures below 34°C. None survived exposure to temperatures of 37°C. and over. Larvae exposed to a temperature of 35°C. for 1 hr. all died.

4. Culex pipiens. The larvae are unaffected at temperatures below 36°C., while none survived at 40°C. to 41°C.

202.* The results of those experiments may be summarised as follows:-

1. Evidence has been obtained to show that the development of the bacterial disease of cotton caused by P. Malvacearum in the seedling stage is confined to a definite range of soil temperature.

2. At soil temperatures of 11°C. to 15°C. infection is slow, and in the case of lightly infected seed may be missed.

3. From 16°C. to 20°C. infection is generally obtained, but again it is not usually serious if other environmental conditions are favourable for the growth of the seedling.

4. From 21°C. to 26°C. infection is severe.

5. Above 26°C. to 28°C. the infection again fades in intensity.

6. Above 28°C. little or no infection is obtained.

7. At 30°C. the plant is generally immune.

Experimental evidence suggests that the regional distribution of the disease caused by P.malvacearum may be explained on these grounds.

8. Some account has been given of the internal changes associated with varying temperatures, and indirect support is given to Faulwetter's work on the spread of the disease in the field by rain.

203. In an endeavour to determine their relations, crop yields and precipitation (also evaporation) data obtained during 20 yr. on 23 field stations in the Great Plains area under natural field conditions over a broad range of soils, climate, tillage, methods, and crop sequences and equivalent to 303 yr. of practical farming are made available, portrayed graphically, and discussed in detail and summary form. The hazards, advantages, and prospects of agriculture in the region are briefly described.

Although annual precipitation is a vital factor in determining crop yield, it appears to be seldom if ever the dominant factor. Not only the seasonal and monthly, but also the daily distribution of the precipitation may be much more important than its annual magnitude. The limitation of crop yield is often due to the operation of one or more inhibiting factors other than shortage of rainfall.

Yields equivalent to 10 bus. or less per acre of wheat have occurred in 75 of 218 crop years during which these investigations were made at 16 stations on the northern Great Plains. During 23 of the 75 years the annual

precipitation

precipitation was less than 12 in. During 52 of the 75 crop years the low yields were due to inhibiting factors other than inadequate annual precipitation. Nevertheless, the composite crop yields averaged throughout the 218 crop years the equivalent of 16.1 bus. of wheat per acre.

The mean annual precipitation of the Great Plains as represented by the 23 dry-land field stations is sufficient to produce crops equivalent to those obtained at the 16 stations if the inhibiting factors are no more potent than they have been during the period covered by these investigations. "With respect to climatic conditions, no extensive portion of the Great Plains as represented by these field stations is markedly superior or inferior to any other portion."

204. Studies on heat regulation in insects have shown that humidity of the air is important to normal insect life. At high temperatures the body temperatures of insects are kept low by the evaporation of water, so that an air humidity above or below certain limits creates physiologically unfavourable conditions. The habit of Anopheles maculipennis of flying only at certain hours of the day and its choice of hibernating places are largely dependent on the humidity and temperature of its environment.

205. The following is largely taken from the author's summary of this paper, which is the 2nd of the series and deals with the seasonal history of Pyrausta nubilalis, Hb., as influenced by climate.

Individuals having different seasonal cycles are not biological species in the ordinary acceptance of the phrase. Different seasonal cycles in various areas are developed and are maintained as the result of climatic impress. After continued impress by a normal climate, the insect develops a rather stable response to this rhythm, which is not immediately lost when the impress originally producing it is removed, nor is it visibly altered in every case during short periods of climatic fluctuation. The insect's physiological constitution has several distinct optima, but the optimum considered as a whole seems to be the one-generation type of seasonal history. Fluctuations in abundance can occur annually in response to variations in climate, and are induced by changes which do not differ greatly in character for both one and two-generation individuals. The effect, even of annual fluctuations in climate, tends to be cumulative. As regards the insect's distribution in the temperate climates, it is seen that one of the chief requirements for successful development is the dormant period under cold conditions. The period of dormancy when occurring under such conditions as prevail in south-western Russia and Hungary is undoubtedly accompanied by desiccation and must be followed immediately

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by a supply of contact moisture in order that pupation may be aided, one generation being produced as the seasonal cycle. Slightly colder conditions than those of Hungary during the dormant period, when accompanied by abundant moisture and followed by favourable conditions during the developmental season, can produce two generations. There is also a certain temperature requirement for the existence and development of two generations, below which moisture is not the principal factor in the determination of the cycle. More important than the latter fact in the direct correlation of the environment with the seasonal development of the insect, is that after this adaptation has continued for a certain period of time like intensities of factors stimulating the organism do not affect it to the same degree as before. This development of different physiological limits in individuals of different cycles is due in part to the intervention of the dormant period, with the physiological change that occurs at that time. It is essential to determine experimentally the part played by the dormant period in the life of the insect, and the effect of environment upon its physiology in aiding the preparation for active devlopment that occurs during this period.

206. There is a marked specialisation in insect cold-hardiness in two directions, ability to withstand long periods of low temperature (quantity factor), and ability to withstand intense low temperature (intensity factor). Hardiness to either factor may, however, be developed separately in some ecological groups and in some individuals. The most characteristic ecological group of insects that is specialised with regard to the quantity factor is the aquatic lake-dwelling group, which is able to withstand long periods of low temperature at or near the freezing-point of water, but of which the author has not yet found any individuals able to withstand ice formation within their tissues. Certain soil insects normally living below the frost-line constitute another ecological group that may be specialised with regard to the quantity factor.

The insects infesting grain and stored products are a somewhat heterogeneous group as regards their ability to survive low temperatures. As a group they are unable to withstand continued low temperatures in a dormant condition. Ptinus fur, L., however, and some species of Trogoderma may be able to withstand dormancy. Tribolium confusum, Duv., cannot survive it, but normally it may recover from temperatures as low as -14°C. With Calandra (Sitophilus) granaria, L., there is more variability with regard to freezing-points, but ability to survive in a dormant condition is limited. This variation occurs in this species as regards hardiness to both the intensity and quantity factors. In Ephestia kuhniella, Zell., there is a decided specialisation with regard to the intensity factor; the larvae cannot withstand prolonged cold while dormant, but when partly dehydrated over calcium chloride can endure temperatures as low as -15°C.

Species normally exposed to extremes of low temperature during the winter months develop cold-hardiness to both the intensity and quantity factors. In the oak-borer group of Coleopterous larvae, individuals develop ability to survive cold in a dormant condition (quantity factor) in September and October, but are then unable to withstand extremes of low temperature. Upon dehydration

or

or gradual exposure to low temperature they become cold-hardy to the intensity factor.

An interesting case of separation of the two factors involved in cold-hardiness has recently occurred in a specimen of Popillia japonica, Newm., which endured cold in a dormant condition for 10 months, but was unable to survive freezing. In this species there occur individuals capable of withstanding ice formation within their tissues and of becoming cold-hardy to the intensity factor.

207. The author concludes that cold-hardiness to the intensity factor of low temperature can be measured by moisture content, under-cooling point and blood conductivity. Conductivity measurements are found proportional to cold-hardiness throughout the whole year. For each species there is a different set of physical constants, which measure the cold-hardiness of that species.

Larvae of Popillia japonica, Newm., which hibernate below the frost-line, do not exhibit any marked body weight changes over winter when kept in moist surroundings, but can be experimentally dehydrated to half their body weight, and then have a survival temperature as low as -28°C. Larvae of Diacrisia virginica, F ., and Isia isabella, S. & A., show a marked water loss when they go into hibernation; up to the time when they can survive freezing the under-cooling point of the blood is the minimum survival temperature, but after that time the under-cooling point no longer measures the total cold-hardiness, which reaches to below -40°C. and there is no free body fluid on which a conductivity reading can be made. Various Coleopterous larvae boring in oak are normally self-dehydrating, but never to the extent of losing all their free water. Although they are resistant to temperatures below -40°C., blood samples can always be obtained. There is a marked periodicity in their cold-hardiness, and also, but to a less extent, in that of P. japonica, whereas there is practically none in aquatic insects.

208. In studies conducted at the University of Wisconsin air temperatures taken at heights varying from 6 in. to 60 in. above the soil surface were higher during the day in cropped areas, such as sugar beets and corn, than in uncropped areas. With a crop such as hemp, where there was a heavy stand, lower temperatures were obtained during the day at the 6-inch and 12-inch heights and higher temperatures at the 36-inch and 60-inch heights, as compared with adjoining uncropped areas. The night air temperatures taken immediately preceding sunrise, when the atmosphere was calm, were higher in the cropped than in the uncropped areas. The greatest differences were found in the hemp. Inversions of temperature were greatest over the uncropped plots.

By the use of an enlarged bulb thermometer the temperature of the surface soil was found to be lower than that of the air in contact with it just before sunrise on calm nights. Mineral soils where the drainage conditions were good showed differences as high as 4.55°C. whereas on poorly drained areas, such as peat soils, the temperature of the surface was seldom more than 1.5°C. cooler than the air in contact with it. During calm weather the temperature of the air in contact with the soil was found to be higher by the use of the copper bulb as well as by the electric resistance thermometer.

209. Records taken at four contrasting stations, namely, (1) completely denuded area, (2) grassed, (3) young forest, and (4) old forest established in the Yale Demonstration and Research Forest near Keene, N.H., showed that the forest and ground covers are very important factors in influencing soil and air temperature, evaporation, humidity, etc.

The complete denudation of the forest and ground cover resulted in a rapid cooling or heating of the surface soil. In the denuded area the moisture content in the first 9-inch layer of soil was higher than in any of the other locations. Evaporation, as measured by the Livingstone atmometer, was also highest there.

Soil temperature records taken at 6-inch, 12-inch, and 24-inch depths showed fluctuations corresponding to, but lower in degree than, those occurring at the surface. At 24-inch the soil temperature was less sensitive to surface conditions than at lesser depths. The forest and grass covers significantly lowered the maximum and raised the minimum surface soil temperatures during the hot summer months. The forest reduced the maximum, minimum, and mean soil temperatures at all depths throughout the entire period 1st July to 31st October except that the minimum at 6-inch was raised by the forest in October. The forest exerted a greater influence than did grass in lowering soil temperature and both the young and the old forest had practically the same effect. As measured by the difference between evaporation of black and white atmometers, sunlight was only 14 per cent. of the possible total in the old forest and but 6 per cent. in the young forest.

210. In studies at the University of Maryland of the effect of modifying the length of light exposure upon soy beans, peppers, lettuce, and radishes grown under high and low nitrate conditions, the soy beans blossomed much earlier and the peppers considerably earlier under a shortened day. On the other hand, lettuce and radishes blossomed sooner under a lengthened day. In the case of soy beans, very little difference was noted in the response to light changes of the high and low nitrogen series, a fact due probably to the leguminous nature of the soy bean. On the other hand, a lack of nitrates delayed blooming in peppers, lettuce and radishes irrespective of the length of day.

Analyses of soy beans showed short-day plants at the time of blooming to have a higher percentage content of total carbohydrates than plants of other treatments. At the same time the percentage of total nitrogen was lower. The normal-day plants reached a similar composition at blossoming time (86 days). Plants subjected to intermittent light failed to respond in the same way as plants receiving an equal amount of light in a continuous application. In the case of soy beans, intermittent-light plants at the time of blooming were low in sugars, starches, and soluble nitrogen and high in insoluble nitrogen. Soy beans lighted at night with electricity did not bloom in 160 days, the duration of the study. Since the percentages of soluble carbohydrates were somewhat lower in the continuous-light series, the authors deem it likely that the carbohydrates were used in growth extension

rather

rather than in fruiting.

211. This volume, one of the American Chemical Society monograph series, discusses the manner in which the green plant utilises solar energy, stressing the results of experimental observations rather than the conclusions arrived at by field observations or empirical methods. Experimental methods have demonstrated the complexity of the subject and emphasised the need for great experimental skill. An endeavour has been made to discuss the salient features of the subject with some consideration of those theoretical aspects which offer promise of fruitful development on the basis of experimental study.

The chapters deal severally with the origin of organic matter, and the cosmical function of green plants, the nature of photosynthesis as determined by observations of gaseous interchange and the formation of organic matter, the products of photosynthesis, the methods of measuring photosynthetic activity, the chemistry of photosynthesis, the energy relations in photosynthesis, and chlorophyll and the chloroplasts.

212. The author explains the importance of being able to determine the probable date of appearance of the codling moth (Cydia pomonella, L.), the time of emergence of the adults, seasonal progress and moment of pupation. The method of studying these problems is described, and the purpose of the present investigation is outlined. It indicates that various factors besides temperature have important effects on development; that experimental results may be made to have direct bearing on the interpretation of results under actual climatic conditions; that the temperature at which development begins is variable; and that the approximations used by various workers in summing temperatures are of little or no physiological significance; that under actual climatic conditions there is no such thing as a thermal constant or sum of temperatures in the ordinary biological sense, and that the temperature should not be summed without various corrections and adjustments for the effects of other factors; that interpretations of conditions may be based on equal-velocity charts for combinations of important factors; that conditions of hibernation are of great importance; and that rainfall and many other factors are of importance at particular periods of life history. The experiments undertaken and the conclusions deduced from them are discussed at length and should be studied in the original. Temperatures, when read for biological purposes, should be taken every hour or two instead of daily and corrected for other conditions. The time for pupation in spring and length of the pupal stage of C. pomonella are influenced by autumn and winter rainfall. Rainfall-temperature diagrams (hythergraphs) show characteristic differences between years when C. pomonella is abundant and years when it is scarce. Rainfall influences the time spent by the larva in the apple, and probably the length of other stages. The falling of the mean temperature from day to

day

day in late summer induces acceleration of development, while its rise in spring is correlated with decreased rate of development. This falling of mean temperature has no influence on the beginning of hibernation, which is probably induced by the activity of enzymes. There is considered to be no reliable basis for predicting the time of the first spring pupation.

213. The author discusses the effect of temperature and humidity on the major pests of cotton in Portuguese East Africa, showing the relative merits of late and early planting. Low yields, attributed to insect injury, principally by bollworms (Earias insulana, Boisd., and Heliothis obsoleta, F.), occurred in cotton sown with the first rains, from December to February, and picked during the cold season from June to August. Attack by bollworms was to a great extent avoided by later planting, only slight damage by the Sudan bollworm (Diparopsis castanea, Hmps.) occurring and the yield being greatly increased, and it is believed that if irrigation were applied in August and September still better results might be obtained.

214. The larvae of the Noctuid, Anticarsia gemmatilis, Hb. (velvet-bean caterpillar) feed extensively on velvet beans (Stizolobium) and also on soybean (Glycine hispida), kudzu bean (Pueraria hirsuta), Canavalia and peanut (Arachis hypogaea). The moth is, however, unable to establish itself permanently in northern Florida and other southern States. This is not due to the direct action of cold, but to the fact that a heavy frost kills all the good-plants of the larvae; and, although the pupal period may be prolonged from 11 days (in September) to 48 days (November-January), it is never prolonged sufficiently to tide over the starvation period. A very little further lengthening of the pupal period would serve to extend the northern limits of its occurrence.

215. Analyses of tree growth, as determined by measurements of the growth rings in five age classes, namely 280 yr. 230 yr. 180 yr. 140 yr. and 75 yr. in western white pine located in the Kaniksu National Forest showed that in northern Idaho there has occurred rather distinct wet and dry periods varying in length from 20 yr. to 40 yr. or more. Apparently the last two decades have been the driest 20 yr. during the past 250 year period. The author points out that foresters should take into consideration the part that variable precipitation plays in forest practice.

216. Growth experiments and chemical analyses carried out with Xanthium pennysylvanicum grown under known conditions of temperature and relative day-length showed temperature to be a determining factor as to time of flower primordia formation. This temperature effect, however, was closely associated with a response to relative day-length. Details are given.

Chemical

Chemical analyses of high-temperature-short-day and low-temperature-long-day plants resulted in ascending carbohydrate-nitrogen ratios in both cases as the plants approached flower primordia formation. A marked difference in the magnitude of the ratios was noted.

A marked accumulation of reducing sugars and condensed sugar forms in the low-temperature hypocotyl radicles was noted, suggesting a physiological predetermination influencing the initial stages of growth.

217. Using as the source of vitamin A etiolated shoots of wheat and white and yellow corn untreated and exposed to the light from a quartz mercury vapour lamp, the author has demonstrated that etiolated shoots may contain small quantities of vitamin A when grown to a height of about 10 cm. to 12 cm. above the ground; that the formation of vitamin A in the shoots is accelerated by exposure to the light from a quartz mercury vapour lamp, but that the short ultra-violet rays involved in the synthesis of vitamin D do not take part in the synthesis of vitamin A; that, within reasonable limits, excessive illumination of the plant tissue does not have a destructive effect on the vitamin A formed in the tissue; and that the amount of vitamin A in etiolated shoots varies inversely with the temperature at which they have been grown.

218. Tests of the effect of electrical illumination on the development of plants throughout a systematic range, including wheat, barley, buckwheat, peas, beans, and cucurbits, were carried out and were successful in the production and maturing of seed in case of the first four named. Details are given bearing upon the apparent possibilities of such work.

219. Varieties of wheat and barley and hybrid material were winter-grown in the greenhouse successfully at the University of Saskatchewan by supplementing daylight with artificial light. Oats varieties and hybrids produced very few seeds. The P_1, F_1, and F_2 generations of Marquillo x Marquis wheat were successfully grown from seeding to maturity during the period 10th May, 1925 to 8th May, 1926.

In general the plants under artificial light headed earlier and grew taller than those receiving daylight only. Delay in the use of artificial light until the plants had considerable growth resulted in later heading, increased height, and larger seed yield. Rakold winter rye, field sown 4th September, 1925, and placed in the greenhouse under artificial light on 15th October headed 5th January, 1926, while that wintered in the field headed 2nd June, 1926. Kharkof winter wheat similarly treated headed 5th January in the greenhouse and 20th June in the nursery.

220. It is a common statement that ultra-violet light is evidently not needed for the healthy growth of plants because

every

every variety of plant can easily be cultivated behind glass which is impervious to ultra-violet light. The author points out that this belief is incorrect; different kinds of glass differ in the degree to which they transmit ultra-violet light and all are not impervious to it; also many tropical and sub-tropical plants grown in England under glass and with every precaution as to temperature and moisture, refuse to thrive as they would in their own country. Such experimental work as has previously been done has rather gone to show that ultra-violet light is actually harmful or even fatal to plants, and the author mentions that previous workers found that a single long exposure of 2½ hr. or repeated shorter ones of even as little as 5 min. per day, had a fatal or a severely stunting effect upon them. In her own experiments, she sought to ascertain whether in any circumstances dosage with ultra-violet light can be of benefit to greenhouse plants. She used a Hewittic quartz mercury vapour arc and gave exposures of 30 sec. or longer. All doses which she used, from 10 min. down to 1 min. had a harmful effect, but when she used doses as small as 30 sec. on a number of successive days, a beneficial action was observed after a certain latent period. Though no more than suggestive this investigation affords an interesting analogy to work at a certain stage in the history of the irradiation of animals. Certain earlier workers exposed rats to ultra-violet light for lengthy periods and in consequence, reported that the effect of the rays is wholly harmful. They entirely missed the extremely important biological action of small doses of the rays.

It would be interesting to know whether glass which transmits ultra-violet rays freely can be usefully employed to increase the growth of fruit and vegetables in greenhouses. It has been stated that an experiment with tomatoes showed that improvement was obtained with this kind of glass.

221. Formulae are given for determining from meteorological data the number of days during which the temperature goes above any given degree. The distribution limits of Beech and Oak are then correlated with certain temperature relations. In Madeira, where the temperature in the middle of every month is above 15°C. Beech retains its leaves only 7 months, Oak somewhat over 10 months. Wherever the duration of temperatures above 10°C. is less than 7 months in the case of beech and 10 months in the case of oak, both trees put out leaves as soon as the temperature reaches 10°C. in spring and change their colour when it falls to 10°C. in autumn. The oak requires at least 3.5 months over 10°C. to carry on assimilation, whereas beech in the plains requires 4 months but in the mountains only 3 months above 10°C. For internal processes which continue in the plant after leaf fall, the oak requires 5 months above 1.5°C; beech in the plains requires 8 months in the mountains 7 months above 1°C. These internal processes appear to cease at about 1°C. The oak can endure nearly 7 months but the beech only 3 months below this temperature. However, neither tree needs such low temperatures.

222. * Two sets of experiments are presented, which were planned to determine the effects on growth and metabolism of

alternating

alternating high and low temperatures. One set gives the rate of growth of first instar larvae of Porosagrotis orthogonia when exposed to various high temperatures for short periods per day, and the other set gives the rate of carbon dioxide production by nearly mature larvae of Chorizagrotis auxiliaris, during similar exposures.

Both experiments point to the same conclusion; in working with temperature it is necessary to consider the time of exposure. They show that larvae removed from a cold room to a warm incubator gradually accelerate their metabolism for several hours, after which their metabolic rate gradually declines over two or three days to a lower constant figure. The combinations of time and temperature which produced most rapid metabolism in the cutworms used were those which are very common in the temperate zone during the growing season.

These results are interpreted as being the resultants of opposing forces. In considering the relation of temperature to metabolism, the two forces concerned may conceivably be the increased activity and increased destruction of enzymes at high temperatures. In considering the relation of time to metabolism, the two forces might be the production of new tissue material and the elimination of waste products. In both cases an equilibrium is reached.

A combination of the time-temperature-metabolism curves gives a three-dimension surface, from which the rate of metabolism or growth for any time-temperature combination may be predicted. This surface has the following properties:-

(1) An optimum combination of time and temperature for the given species: a point at which the rate of growth reaches its highest absolute value.

(2) A shift in the time position of the optimum line with changes in temperature, the optimum time being shortened at higher temperatures.

(3) A series of zones of equal growth rate, surrounding the absolute time-temperature optimum. This makes it possible to secure any given growth rate less than the maximum by several combinations of time and temperature.

(4) A correlation of the limits of growth in time and temperature with the zones of dormancy and the thermal death points.

223. The agricultural productivity of a region is conditioned by climate, topography and soil, adapted crops and adequacy of cultivation. The climate of the grassland is favourable throughout to the growth of grasses and unfavourable to woody vegetation. Within the general climatic control, differences in precipitation and evaporation result in different types of grassland. General similarity of climate and vegetation have combined to produce similar mature soils throughout the prairie, but the soil profile varies with decreased precipitation and less luxuriant vegetation from east to west. East type of vegetation, including its rooting habits, indicates the possibilities of certain types of crop production. Cereal crops and certain legumes are best adapted to grassland since they have much in common (rooting habit, tillering, overwintering, etc.) with the native vegetation. The problems of the agronomist are also the problems of the

ecologist

ecologist - modifying an environment to make it conductive to the growth of plants.

224. Reference is made to studies of the effect of rainfall, temperature, wind velocity, evaporation, and insolation, with 13 consecutive plantings at 28-day intervals of Calauan Yellow Flint, a native variety, and Mexican June, a foreign variety. The results obtained are summarised as follows:-

"(1) The season most favourable for corn production is when the rainfall is about 312.6 mm.
(2) Temperature, insolation, and wind velocity had no relation to the production of corn. (3) The best months for planting Calauan Yellow Flint corn were found to be March, December, and January. (4) The best months for planting Mexican June Corn were found to be March, September and June. (5) The month which proved unfavourable to corn production was August, when the rainfall reached about 752.7 m.m. to 948.4 mm. (6) Evaporation influences corn production. Highest yield was obtained when the evaporation was high."

225. Alterations following exposure to cooling of rye, wheat, pea, maize and buckwheat roots can be presented graphically by a curve corresponding to that of temperature. Freezing temperature is not constant for one and the same root, as the attainment of freezing depends upon individual peculiarities and the range of temperatures employed.

The killing point of roots is lower than the freezing point. The lowest resistance is shown by the cortex and root hairs, the highest by the meristem, and the intermediate by the central cylinder.

A study of the vital reactions as regards root cells showed that buckwheat has the greatest acidity. A positive correlation was noted between cold resistance and alkaline reaction and a negative correlation between the acidity and resistance to cold, the central cylinder being approximately neutral. This correspondence between reaction and resistance to cold is thought to be of practical importance. Acid reaction may hasten the death of cells in freezing, and this is said to be evidenced by experiments with red cabbage sections. Even very weak acid concentrations correspond to a significant lowering of cold resistance in the cells. Weak alkaline concentrations, on the other hand, correspond to important increase of cold resistance. Precipitation of nitrogenous materials in acid media requires a small temperature decline and a slighter water removal than in alkaline media.

It is concluded that the disturbance of physicochemical equilibrium of the plasma in freezing must proceed much more rapidly in cells showing acid than in those showing alkaline reaction.

226. *During the summer of 1926 a survey of the apple-producing sections of Virginia, West Virginia, and Pennsylvania was made in order to determine the economic, geographic and

climatic

climatic effects on the apple industry of these three States, and the results show some interesting relations of temperature to the yields of apples. In the survey, data were obtained for Martinsburg, W.Virginia giving the dates of blooming of the York Imperial apple and also the percentage of a full crop for the years 1911 to 1926. With this material an effort was made to find the day-degree temperature-constant for apple blooming at that place. Various periods of time were chosen, such as 1st January to blooming, 1st February to blooming, and from the blooming date of the previous year to blooming of the next. The accumulations found were unsatisfactory in that no close relation could be found between the constants.

There is a close relation between spring temperatures and variations of the blooming date, as warm weather at this season hastens blooming and cooler weather retards it. At Wauseon, Ohio, the period most effective in controlling blooming had been found to be 21st March to 30th April, but in Virginia the period was from 7th February to 28th March. The relation between apple yields and the temperatures during this period was so pronounced in Virginia as a whole that the same period was applied to the Martinsburg figures. The result was very gratifying for the coefficient of correlation was -0.85 ± 0.04 against -0.79 ± 0.05 for the whole state.

The influence of the weather during the week of blooming was also studied in an attempt to correlate various elements with yield. In this study, for which Martinsburg blooming dates were used, the results were disappointing. The only element exhibiting a relation to yield was minimum temperature, and even that was too small to be of much significance.

227. The present study was confined to northern-grown onions of the globe type, the average freezing-point of which was found to range at and near 30°F., varying somewhat with the temperature at which the plants are grown and are held in storage. Onions may undercool without freezing, if not subjected to rough handling when cooled to temperatures below their normal freezing-points. Freezing injury is readily confused with the results of physiological breakdown due to any of several causes. Onions having only the outermost scales injured by freezing may as a rule be salvaged if allowed to dry out.

228. This contribution to a joint discussion on the problems arising in the cultivation of cotton by irrigation on the heavy alkaline soils of the Gezira, is based on physical and statistical investigations made whilst the author was working temporarily at the Gezira Research Farm, Wad Medani, Sudan. The soil of the Gezira has a hard layer at a depth of about 3 ft., and it is known from field studies of water movement after irrigation, that but little of the added water percolates below this depth. Cotton roots, exposed by washing away the soil with a jet of water, did not penetrate this layer, but were confined to the first 2 ft. of soil. Measurements of the apparent specific gravity of soil by the waxed block method were made at a series of depths down to 4 ft. The density of the moist soil increased from 1.65 gm.

per

per cc. at the surface to a maximum value of 1.80 gm. per cc. at about 3 ft. (the weight of dry soil in gm. per cc. increased from 1.29 to 1.49). The high value at 3 ft. shows that the closeness of packing of the soil particles is one factor in the hardness and impermeability of this layer. But even when this factor is removed by uniform packing of sieved soils in columns in the laboratory, there are marked differences in permeability in samples taken from different depths. The rate of movement of water decreased steadily from the surface to very low values in soils taken from the third foot; below this depth the rate of movement increased owing to the flocculating action of the sodium sulphate present. The possibility of increasing the permeability of the field soils by cultivation methods was discussed and attention drawn to the desirability of investigating the effects of delaying the cultivating of the fallow preceding the cotton crop.

Data for the yields of cotton on the older experimental areas in the Gezira were subjected to a statistical analysis. In any one year the yields of cotton grown under miscellaneous rotations at Tayiba from 1911 to 1922 decreased steadily for each additional crop of cotton previously grown on the plot. It has been suggested that this deterioration may arise from the intrinsically bad effect of water on a saline soil. Except in the earliest years the yields were not diminished by the previous growth under irrigation of other crops, chiefly lubia and dura. These crops appear to counteract the deleterious effect of irrigation, probably by the introduction of organic matter or the fixation of nitrogen. In rotation experiments at the Gezira Research Farm, the deterioration is least in the rotations including the leguminous crop, lubia. The correlation between the monthly distribution of rainfall and the yields of cotton in five rotation experiments at the Gezira Research Farm for the period 1918 to 1925, were investigated. For the normal three-year rotation, lubia, fallow, cotton, there was a striking agreement between low yields and high early (May and June) rainfalls ($r = -0.94$). Two-year rotations and continuous cotton did not show this effect, but the yields were connected with the rainfall at other periods. Thus late rains (September and October) had a bad effect, which increased in magnitude for the rotations in the order, fallow - cotton, dura-cotton, lubia-cotton, continuous cotton; the bad effect of late rains increased as the duration of the fallow preceding the cotton crop decreased. This probably indicates the importance of the fallow in increasing the permeability of the soil to water.

Some support was given to the conclusions from the three-course rotations by the results from three-course rotations at Tayiba and Barakat. Each of these estates had 2,000 acres of cotton annually during the 6 yr. for which the local rainfall data were available. The correlation coefficients between yield and May and June rainfall were -0.81 and -0.50. No satisfactory explanation of this effect could be offered, but the hypothesis was advanced that the bad effect of early rains arises from a loss of available nitrogen from soils containing very little decomposable organic matter during heavy rains in July and August when these have been preceded by an early rainfall sufficient to allow nitrification during May and June. In two-course rotations the presence

of

of decomposable organic matter would probably reduce this loss just as in humid climates the introduction of bulky organic matter and stubbles reduces the loss of nitrate during the winter months.

It was concluded from a consideration of the rotation and manurial experiments at the Gezira Research Farm and from general observations that, after the water supply, the most important soil factor in the growth of cotton in the Gezira was the nitrogen supply.

229. Measurements have been made of illumination in the shade and in the open by means of apparatus indicated. The most satisfactory way of expressing the illumination at a shaded site, in relation to its flora, is as a percentage of the diffuse light in the open, this percentage being here termed the daylight factor. Data are presented concerning the distribution of various plants in terms of the daylight factor. This factor may be as low as 1 per cent. to 2 per cent. on the floor of a wood of mixed deciduous trees in autumn, and less than 0.06 per cent. in especially heavy shade under rhododendron.

230. The question as to what factors produce in milk anti-rachite properties or increase these properties, and whether these properties of milk can be artificially induced or prevented, has for many years been studied by numerous investigators and has formed the object of more or less exhaustive enquiries.

The writers draw the following conclusions from the results of their work:-

Pasture milk differs from normal stall-fed milk in its anti-rachitic properties. Normal winter feeding provides either very scanty anti-rachitic properties or none at all. The anti-rachitic effect of pasture milk could be attributed partly to the direct action of the sun's rays on the cow, and partly to the vitamin D content of the pasturage.

The writers consider that the use of artificial ultra-violet rays on the farm under given conditions is worth a trial.

231. *It is of some interest to give for 1926, a brief sketch of the part played by climate in the production, both as regards quantity and quality, of sugar beet. Variations of the principal meteorological elements - temperature, rainfall and sunshine - stamp as we know, on environment its particular character. Examination of the graphs published by the Brussels Observatory enables an account to be given, for each climatic factor considered, of the importance of observed fluctuations from the normal curves of each.

Analysis

Analysis of these curves leads us to conclude that 1926, although on the whole of normal temperature, was a wet year with extremely feeble sunshine.

Up to mid-April the early months showed an excess of temperature. After mid-April, a series of months with deficient temperature began. May was very cold, an observation which recalls the wretched temperature conditions under which the germination of the sugar beet seeds had to take place; noting here that the varieties planted did not all struggle with the same vigour against the inclemency of the weather. If it is true that the seed contains in itself the future of the plant, it is nevertheless necessary in order that it should develop a robust plant that the germination should take place in a steady manner under sufficient temperature conditions. As a result, in most of the cases of deficient production the primary cause of the loss of weight of the yields is certainly the slowness of the germination of the seeds.

Besides, as a reaction against adverse conditions of climate and soil, many plants manufactured cellulose matter longer. This modification of the cellular tissues gives a sugar beet with a stringy root difficult to cut with a root cutter.

July and October were excessively wet; in July the rainfall amounted to 138 mm. (normal 77 mm.) and in October to 178 mm. (normal 70 mm.). The total rainfall for the year amounted to 843 mm. (normal 740 mm.). As the quantity of organic substance elaborated is related to the amount of rainfall and to sunshine rather than to the heat received, the quantity of sugar produced depends principally on the intensity of the illumination. Now, during 1926, sunshine was deficient in all months. The number of hours in the year during which the sun remains visible is on the average 36 per cent. of the total number possible. In 1926 the average was only 29 per cent; there were actually 1285 hr. of sunshine (normal 1756 hr.) out of a possible total of 4456 hr.

In view of the considerations noted above we cannot absolutely affirm that the quantity of sugar elaborated is proportional to the amount of light, but we can nevertheless show the close correlation existing between the two factors by giving the following particulars:-

1. Reduction of sunshine in 1926: 36 per cent. - 29 per cent = 7 per cent.

2. Reduction of sugar content of sugar beet;

a) 29th November 1924: average content of sugar beet in Hesbaye 16.80 per cent.

b) 30th November 1925: " " " " " in Hesbaye 16.70 per cent.

c) 29th November 1926: " " " " " in Hesbaye 15.60 per cent.

The years 1924 and 1925 can be considered as normal from the point of view of their climatology during the growth period of sugar beet. Setting aside the figure for 1924, the diminution in sugar content in 1926 compared with 1925 is also 7 per cent. approximately.

In pointing out the similarity of the percentages found

we

we have wished simply to insist on the value of intense illumination as a factor in the elaboration of sugar in sugar beet normally provided with chlorophyll.

232. *Penicillium italicum and P.digitatum, the two fungi most commonly producing soft rot in citrus fruits, are in general affected similarly by different temperatures.

On culture media as well as on orange fruits both appear to have nearly the same optimum temperature for development. The differences, however, between the rate of growth at the optimum as compared with the rates at higher and lower temperatures are greater with digitatum than with P.italicum.

In most cases the rate of development of decay was much more rapid at the stem end than at the stylar end of the orange fruits. The percentage of decay in most cases was also greater from injuries near the stem end than from equal injuries near the stylar end.

In lots of fruit inoculated with italicum and held, respectively, at 66.8°F. 74.8°F. and 80.6°F., nearly all fruits showed decay in 4 days, while lots held at 86°F. and 57.5°F. showed similar decay in 8 days, and lots held at 50°F. showed similar decay in 12 days.

In lots inoculated with digitatum much the same general relation of temperature to time and percentage of decay was noted except that apparently the temperatures above and below the optimum had a greater relative inhibiting effect than in the lots inoculated with P.italicum.

233. *The results of the experiments noted in this paper may be summarised as follows:-

(1) In Egypt, during the periods of germination and increase in height of the cotton plant, the soil temperatures are rising and the amplitude of the temperature wave is at its maximum.

(2) In Egypt, the maximum soil temperatures decline while the minimum soil temperatures remain constant, thus resulting in a gradual decrease in the amplitude of the daily temperature wave during the branching and flowering periods.

(3) In Egypt, throughout the soil zone occupied by the roots of the plant, the temperature is the same, the amplitude of the daily temperature wave small, and the temperature is constant during the boll development and maturation periods.

(4) The main effect of irrigation on soil temperatures is to reduce the amplitude of the daily temperature wave, no sudden change of temperature in the root zone taking place.

(5) From a consideration of the range of air temperature in other cotton producing countries, it seems probable that the characteristics of the soil temperatures during the boll development and maturation periods are the same for all countries.

The

234. The occurrence and subsequent development of the mosaic disease of winter wheat is closely associated with normally active growth of the seedling.

The period of infection is limited to the early seedling stage. Under favourable environmental conditions, an interval of 1 week from the date of seeding is sufficient to permit a high percentage of rosetted or mottled plants. Where the environmental conditions were less favourable, mottling occurred at time intervals too short for the development of rosette.

The disease developed only within a relatively restricted soil temperature range. In a test at the four different constant soil temperatures, 10°C., 16°C., 23°C., and 30°C., the disease occurred only at 10°C. and 16°C. The leaf mottling of the Currell variety occurred to about an equal degree at each of the two soil temperatures, while the rosette and the leaf mottling of the Harvest Queen variety developed best at 16°C. No indications of either rosette or mottling appeared in either variety at the higher two soil temperatures.

A high soil moisture content decidedly favoured the occurrence of both rosette and leaf mottling, whereas a medium soil moisture content was proportionally less favourable. No indication of symptoms appeared under the low soil moisture contents.

Under the controlled conditions described, no shifts occurred in the soil temperature and soil moisture optima when the value for either factor was altered.

Rosette developed under field conditions at soil temperatures strikingly similar to those found most favourable in the controlled tanks. Faint mottlings of both varieties, however, developed at somewhat higher soil temperatures under these fluctuating conditions.

In the case of seedlings transplanted from infested soil to uninfested soil, the age of the seedling at the time of transplanting appeared to be a factor influencing the development of the disease; that is, the percentage of diseased plants increased only within limits for increased periods of exposure to infested soil.

The rosette disease infection curves for the seedlings of six different ages varied with the transplantings on different dates. These relations are in direct line with those obtained in the tank and the field soil temperature experiments, the disease developing only at or below 15°C.

235. * Pot experiments were conducted in which Japanese millet and soy beans were grown with varied amounts of potash and of water supplied to the soil, in order to ascertain the relation of the water supply to the availability of the soil potash and the extent to which additions of soluble potash would overcome the lack of water.

Four

Four series of pots were prepared with relation to potash. Series A contained soil that had received no potash fertilisers for 30 yr. Series B had potash added to the soil of A. Series C contained soil that had received annual applications of potash fertilisers for 30 yr. Series D had potash added to the soil of C.

Each series received maximum, medium and minimum supplies of water, based on the water-holding capacity of the soil. The soils with the least water were more like a naturally dry soil than a soil during a drought because the limited quantities of water were added at short intervals.

The experiments were conducted during two seasons. In the first season, the supplies of nitrogen, phosphoric acid, and potash were at the rate used in the field from which the soils were obtained. The supplies of these for the second season were much increased as there were indications that the first year's allowance was too small.

Both millet and soy beans on the soil without potash for years gave yields which varied directly as the supplies of water. The percentages of potash in the crops and the quantities by weight indicated that the soil potash had a low solubility and the amount available for crops was dependent on the supply of water.

The millet crops when supplied with available potash were not much affected by lessened supplies of water. The addition of potash increased the production of straw proportionally more than that of seed.

The soy bean crops were affected by both potash and water supply and in about the same proportion. Potash increased seed production proportionally more than the yield of straw. On the soil without potash for years, soy beans were slow to mature, and analysis of the seeds, pods, and straw indicated that, with the lack of potash, the nitrogen was not transferred freely from the straw and pods to the seeds.

The plentiful supply of available potash in series B and D in the second season gave an increase in absorption of potash by the crops which was proportionally greater than the increase in plant growth accompanying it.

Available potash with the minimum supply of water enabled millet in the second season to produce 92 gm. of seed and 112 gm. of straw, while without added potash but with abundant water it yielded 75 gm. of seed and 64 gm. of straw. Soy beans under parallel conditions produced 74 gm. of seed with the added potash and 45 gm. without it, but the straw was affected by the water supply.

236. (1) The replacement of forests by field crops or grassland probably tends to increase the general rainfall of the district

slightly

slightly; their replacement by bare ground probably tends to decrease the general rainfall slightly.

(2) Forests increase the local rainfall by 1 per cent to 2 per cent., this effect being due to the increase in the effective level of the ground by the height of the trees, and by the greater friction of the wind with the tree surface compared with open ground.

(3) To this may be added, in favourable mountain situations, an increased supply of water collected mechanically from clouds which envelop the forests.

(4) Afforestation of grass or crop land probably increases the local run off by 10 per cent. to 20 per cent., this amount being made up, partly by the decreased loss of water in evaporation and transpiration, partly by the slight increase of rainfall. This is likely to be the most noticeable effect of afforestation. Afforestation of bare ground would decrease the run off, but this effect would be masked by the much greater regularity of the flow.

(5) Forests, drawing their water supply from deep sources, possibly exercise a slight mitigating effect on droughts.

237. * Evaporated apples of uniform initial moisture content, made from 5 varieties of rather widely varying types and given 4 different treatments preparatory to drying, were stored at a temperature of 20°C. to 30°C. in atmospheres having humidities ranging from complete saturation to complete dryness for somewhat more than 3 years, with frequent examination.

The material in all cases either absorbed or gave up moisture until a new moisture content in equilibrium with the moisture of the chamber had been reached.

At relative humidities of 18.8 per cent. or less, the material retained its original colour, odour, and flavour unchanged throughout the entire storage period. Evaporated apples can be preserved indefinitely by sufficiently reducing the moisture content of both the material and the storage chamber.

At relative humidities between 47 per cent. and 80.5 per cent. growth of moulds and yeats did not occur, but the fruit developed progressive brownish discoloration, rancid odour, and abnormal, bitter flavour, which rendered the material unpalatable and unmarketable before the expiration of the storage period. The rate at which these changes occurred increased with increase in humidity throughout the series.

These alterations in colour, odour and flavour became evident within 1 year in fruit having the moisture content reduced to from 9 per cent. to 10 per cent. when the material was loosely piled so that air had free access to it. If the changes are produced by enzymes, the enzymes concerned are not destroyed by treatment of the fruit with sulphur dioxide or sodium chloride or by heating it to 80°C. prior to drying.

At

At relative humidities higher than 80.5 per cent., the absorption of moisture was sufficient to permit rapid and abundant development of moulds and yeasts, which destroyed the material within a few months.

Exposure to fumes of sulphur dioxide, immersion in 2 per cent. sodium chloride, or heating in steam to 80°C. preparatory to drying, did not prevent the development of discoloration at low humidities or the growth of organisms at the higher humidities, all the lots kept at any given humidity ultimately reaching the condition of the untreated control. Of the various treatments, that with sulphur dioxide retarded the development of these changes somewhat longer than the others. Sodium chloride was next in effectiveness, but its reaction with some constituent of the fruit produced a characteristic alteration of colour in some varieties.

The several varieties showed considerable differences in the rate at which deterioration developed, deterioration being most rapid in the variety which combined highest acidity and astringency with lowest content of sugar.

Evaporated apples are highly hygroscopic. Material having 13 per cent to 15 per cent. moisture is in approximate equilibrium with the atmosphere over sulphuric acid of 1.30 specific gravity, having an osmotic pressure approximating 750 atmospheres. Fruit having the standard moisture content of 24 per cent. is in approximate equilibrium with air of 75 per cent. relative humidity at 30°C., and will rapidly absorb moisture when the atmospheric moisture rises above this value.

Adequate protection of evaporated apples against deterioration in prolonged storage involves thorough drying and careful packing of the material and control of the humidity of the storage room. By thorough drying is meant the reduction of contained moisture, not merely to a point at which mould growth cannot occur, but to a lower point at which oxidations and other changes not dependent upon the growth of organisms are arrested. Control of humidity in the storage room implies maintenance of atmospheric humidity at or below the point of equilibrium with the material. Careful packing involves the use of the most efficient means of preventing access of atmospheric oxygen to the material.

The temperature of the storage room plays a very significant role in determining the rate and extent of deterioration. The present study is not concerned with the effects of storage at various temperatures, all the material having been held at temperatures ranging between 20°C. and 30°C.

228. * The response to curtailed periods of daylight shown by several species of economic importance which had not been previously tested is here described. It was found that Lespedeza stipulacea and striata did not thrive under short days. Clarkia, Godetia, and Hordeum vulgare, when subjected to a 10 hour day, flowered later than the control plants which grew taller. Senecio vulgaris subjected to 10 hour days flowered at the same time as the

control

control series. There was, however, a marked difference in the rate of elongation of the stem: the controls grew taller. The biennial Pastinaca sativa under a 10-hour day produced well-formed roots in the first year; in the second year these roots contained more food substance (after flower production) than did control roots. The control plants grew taller. It is possible for Avena sativa to function as a biennial when subjected to short periods of daylight.

By subjecting Trifolium pratense at different growth stages to shortened periods of daylight it was demonstrated that the rate of elongation of the stem was controlled by short days. Plants that possessed tall stems and flower buds before being placed under short days flowered under a 10-hour period of daylight.

In the case of several species including Anthoxanthum odoratum, Dactylis glomerata, Phleum pratense, and Trifolium pratense, it was found that plants which were prevented from flowering in one season by the influence of short days flowered earlier in the subsequent season when placed under natural conditions than did controls.

Dactylis glomerata and Phleum pratense produced less dry weight of top growth under shortened days. The leaves of such plants were rich in protein. The leaf sheaths did not develop as did the controls, and were poorer in fibre. The C/N ratio was lower in the treated non-flowering series.

Helianthus tuberosus was found to produce approximately as much dry weight under 10-hr. of daylight as when receiving the full period of daylight. The 10-hour plants yielded more tubers in the growing season of 6 months. The stems of the control plants contained more inulin and were taller than those of the 10-hour series.

Phaseolus multiflorus when subjected to shortened periods of daylight does not elongate. The short stems are rich in starch and bear thick tough leaves with long palisade cells. The roots become secondarily thickened and contain much starch stored in the wood parenchyma formed.

The results obtained have been considered from the standpoint of the C/N theory of flower production, discussed in a previous paper and by other workers. Generally it may be said that the chemical evidence so far collected indicates that there is a correlation between the chemical composition as expressed by this ratio and the behaviour of the plant. In the opinion of the writer it would appear that the length of day factor governs the utilisation of the carbohydrates manufactured and the rate of the stem elongation, and so influences the C/N ratio.

239. This pamphlet sets out the relations between climate, plant distribution, and geography in Germany. Its object is to provide a basis for the elaboration and classification of the phenological observations organised by the German Phenological Service. It is hoped that the material presented will also be found useful for those occupied with questions important to agriculture and forestry, such as the application to different districts of the results of field experiments, the cultivation of different varieties of crops, etc.

The country is divided into eight main climatic districts, each district being divided into a number of sub-districts. The division is made on the basis of meteorological elements supported by indications from the flora, from phenological data, and from forest and agricultural conditions. The eight districts are as follows:-

A. NORTH GERMAN PLAIN.

I. North Atlantic.
II. Baltic.
III. Sub-sarmatic.

B. MIDDLE AND SOUTH GERMAN MOUNTAIN AND HIGH LAND.

IV. Mountain and Hill Land.
V. Pine Forest Region, Central and South German mountains.
VI. Alpine District.

C. WEST AND SOUTH GERMAN PLATEAU.

VII. Rhine District.
VIII. Swabia Bavaria Plateau.

Ten map charts give the following particulars:-

(1) Distribution of temperatures.
(2) The average yearly minimum temperature compared with the limits of growth of Erica tetralix (close correspondence is shown).
(3) Yearly variation of the mean monthly air temperatures.
(4) Average annual rainfall.
(5) Number of days of snow and the distribution of the relative humidity of 72 per cent. and less in the three summer months, June, July and August.

(6) Distribution of flora.
(7) Distribution of woodland species.
(8) Distribution of agricultural crops.
(9) Distribution of date of middle Spring (taken as the beginning of apple blossoming).
(10) Distribution of mid-summer date (taken as the beginning of the harvest of Winter Rye).

Full explanations of the maps are given in the text.

240. Observations at the University of Maryland upon the behaviour of peas planted at frequent intervals showed very little, if any, correlation between the total hour-degrees of heat above 40°F. and the time required to reach blossoming. In a given season it was apparent that blooming occurred upon the reception of a fairly constant amount of heat, regardless of time. In general, as temperatures rose yields declined rapidly, the loss being largely in less pods rather than in the number and weight of peas per pod. High temperature apparently was harmful at any stage of development and is considered the most potent factor influencing growth and yield.

241. * 1. The soil temperatures in Egypt at a number of depths have been recorded by means of continuous recording thermometers. In general, the records show that the amplitude of the temperature wave at the surface of the soil is considerably greater than the air temperature wave. There is, however, a considerable damping of the wave with depth, no daily variation in temperature being observed at a depth of 100 cm.

2. No definite relation between the air and soil temperatures could be traced. The maximum air temperature was recorded in May and the maximum soil temperature in July.

3. The amplitude of the temperature wave decreased with increase in depth. The decrease in amplitude of the soil temperature wave is not regular owing to variations in the physical properties of the soil layers. Between any two depths, the ratio of the amplitude of the temperature waves is constant throughout the year. The amplitude of the soil temperature wave bears no relation to the amplitude of the air temperature wave.

4. The time of maximum temperature at the soil surface is constant throughout the year at 1 p.m. The times of maximum temperature at depths below the surface lag behind the time of surface maximum, but they are constant throughout the year. When plotted against depth, the times of maximum at the various soil depths lie on a straight line.

5. The time of minimum temperature of the surface soil is variable and occurs just before sunrise. At depths below the surface the times of minimum lag behind that of the surface though the time lag in the minimum is not so great as the time lag in the maximum. When plotted against depth, the times of minimum lie on a straight line.

6. Three types of alteration of the phase of the temperature wave are recorded: (a) an alteration with season, (b) an alteration with depth, and (c) an alteration dependent upon the direction of flow of heat in the soil below the zone of daily variation in temperature. As a result of the alteration in phase of the temperature wave, the duration of heating and cooling varies with depth. The greater the depth, the greater the period of heating and the shorter the period of cooling.

7. Owing to the seasonal and depth alterations in the phase of the temperature wave, the depth of the zone of daily variation in temperature is variable, being greatest in winter and least in summer.

8. The presence of cloud at night has been shown to result in the raising of the temperature of the surface soil due to the prevention of radiation and the conduction of heat from the hot layers of soil below the surface.

9. The valuation of the summer fallow by means of the soil isotherms is discussed.

10. It has been shown that the soil layer in which the micro-organic population is most dense, in which the germination of the seed takes place, and in which the roots of young plants are situated, is subject to both large daily and seasonal variations in temperature.

11. It has been shown that the supposed sudden fall in temperature of the surface of rocks at sunset does not occur. It is indicated that rock shattering as a result of temperature changes probably takes place soon after sunrise.

242. Soil moisture determinations made at Cornell University in three single Jonathan apple tree plots 20 ft. square, isolated by trenches and drains and differentiated in cultural treatments failed to show any material differences. The treatments were as follows:- (1) soil covered with waterproof paper, (2) soil tilled, and (3) same as (2) but with the tree cut off at the ground. This was also the case in a fourth plot in which weeds were allowed to grow after 15th June. The Jonathan tree in the covered soil made normal growth, fruited normally, and apparently obtained sufficient moisture from the original supply and from capillary action. The majority of the roots were found in the second foot of soil.

Comparing the behaviour of apple trees in soil management studies at Laurel, Ind., with the behaviour of apple trees in New York, the author concludes that in the East, because of greater humidity and more abundant rainfall, soil moisture is much less a limiting factor.

243. *Three years of study of the emergence of the Mexican bean beetle (Epilachna corrupta Muls.) from hibernation shows that there is a definite relation between precipitation and the emergence of the beetle and that the percentage emerging is influenced directly by the temperature during the period of rainfall. It is also apparent that heat alone is not sufficient stimulus to produce emergence, as no beetles emerged on some of the hottest days during the season, and that the period of emergence is governed by a combination of the two factors. Emergence rarely occurs when the mean temperature is below 55°F. and reaches its maximum at a mean temperature of 58°F. to 69°F. Beetles in hibernation respond to the effect of artificial precipitation during the emerging season.

244. * Tomato moth larvae, both parasitized and unparasitized by the Tachinid, M. Quadripustulata were subjected to different constant humidity percentages at constant temperature during the pupal period of both host and parasite. The effects of the moisture on the length of the pupal period and the viability were noted.

It was found that as the humidity increased the viability of the host decreased, while that of the parasite increased. Both host and parasite showed a maximum rate of metamorphosis near 73.4 per cent. humidity at 27°C.

245. In an investigation to determine the effect on plants of removing definite regions of the spectrum at the blue-violet

end,

end, several widely different varieties of plants were grown in five separate greenhouses so constructed that practically all conditions except the quality of light could be kept alike in all houses. General observations were made on vegetative vigour, flowering, and fruiting. The height was measured weekly, chemical analyses and microchemical tests were made, and anatomical changes were followed in some cases. The results obtained are detailed for the different wave-lengths.

The results as a whole indicate that, while ultra-violet rays are not indispensable, the blue-violet end of the spectrum is necessary for normal, vigorous growth of plants.

246. * A. Plan of the Experiments.

The professional literature often gives uncertain information as to what temperature is most convenient for growing a plant. Especially for plants which are to be forced in hotbeds the information is very vague and often varies with the different sources. This is probably caused by the fact that the temperature in a bed made of manure or other organic material cannot easily be regulated. But in the electric hotbed the temperature can easily be regulated by hand, and still better by mechanical instruments (thermo-regulators, time switches etc.). For this reason we have in the spring of 1927 at the Vegetable Experiment Station at the Agricultural College of Norway begun to study the growth of different plants under different temperatures. In 5 hotbeds consisting each of 12 sashes the temperature of the soil as well as of the air has been kept as far as possible constant. This has been done by the help of electric cables coupled to thermostats. No. 1 was kept at 8°C., II at 12°C., III at 16°C., IV at 20°C., V at 24°C. In two of the beds, IIIa and Va, the temperature of the soil at a depth of 20 cm. was kept at 20°C. and 28°C. respectively, while the temperature of the air has changed according to the weather, except that in IIIa it was not allowed to exceed 20°C. and in Va it has not been above 28°C. One bed IIa has been quite without artificial heating and the temperature of the air has, as in IIIa, been allowed to reach but not exceed 20°, by the heating of the sun. Ia has been without sashes so that it had growth conditions as in the open.

B. Results.

By growing radishes in these hotbeds at different times from March to December 1927 under the different conditions of light at different seasons we have gained results of great interest when trying to find a standard temperature in radish beds, and the correct density of the plants. It seems that the latter should differ according to temperature and light: in the month of May for instance when the day is long, and the sun is high in the sky, with a constant average temperature, 600 plants per sq.m. can be grown in the bed, but in March with shorter days and weaker light, 400 plants should be the maximum.

Also, under the same conditions of light, fewer plants can be grown per sq.m. in a high temperature than in a low, as there will be bigger leaves at a high temperature than at a low temperature, and they will want more room. The formation of the radish depends on a certain correlation between temperature and light (intensity of light + length of day).

Radishes grown in a temperature of 16°C. or lower are well formed and fine, whereas at higher temperatures expecially with the less favourable light conditions in early spring they will often grow long and deformed, sometimes even of quite grotesque appearance. The higher the temperature, the uglier and more deformed and long the radishes will be.

At

At 22°C. to 24°C. in early spring very few plants can be used. With the better light conditions later in the spring there will be more plants with radishes and gradually they will become more shapely.

It will be seen that the less satisfactory way in which the plants form radishes at higher temperatures is partly dependent upon the conditions of light. If sown less densely the formation of the radishes will be more satisfactory even at higher temperatures. But it is after all not a question of light only. Our experiments with wide spacing between the plants in summer show that at higher temperatures there will be more plants without radishes than at lower temperatures.

When trying to standardize radish culture it should be remembered that it is unnecessary and even positively harmful to have a higher temperature than 14°C. to 15°C. for the earliest forcing. Especially is a higher temperature to be avoided during the germination and early growth. Later in the spring with good light the temperature of the air may be allowed to rise to 18°C. to 20°C. when such a temperature can be obtained from the sun. A temperature of 12°C. to 13°C. gives extra fine radishes and fine small leaves which do not have to be cut off when the radishes are taken to market.

Radishes forced at this temperature will be ready for use shortly after the plot forced at 14°C. to 16°C. It will therefore be profitable to start the two plots at the same time and later go on with new plots and gradually raise the temperature as the light conditions are bettered with the advancing spring (12°C. to 14°C. to 16°C.) till it is possible to pass over to cold frames and open ground.

C. Rules for artificial temperature and density of plants for early and late forcing of radishes.

a. Early forcing (with unfavourable light, February-March).

1. Temperature: When the seed is sown, the temperature at the depth of sowing (close to the surface) should not be more than 12°C. Then the seed will germinate in 5 days. If the temperature of the soil is regulated by a thermostat, it should be set at 14°C. and be placed 5 cm. to 10 cm. below the surface. The temperature at the germination depth should then be 12°C. During the first few days after germination the temperature of the air should not exceed 12°C. to prevent the seedlings from growing too tall; later, in sunny weather, the temperature may be allowed to rise to 16°C. before ventilating.

2. The seed: The seed used for early forcing must have good germinating power and germinating energy, must be large and of uniform size. If it is of variable size the smallest seed must be sifted out. The smaller grains will germinate slower and form leaves without forming radishes, and at the same time stand in the way of the good plants and rob them of the light of which there is little enough at this time of the year.

3. Density of plants: The earlier the forcing is begun, the less light is available for the plants. If sown early the plants must therefore be sown less densely than at later sowing. With forcing in February-March (sowing in last half of February) the density should not be more than 400 plants per sq.m.

4. The finest radishes, nicely formed and with small, short leaves are always obtained by keeping the temperature of the air under 14°C. and by letting the thermo-regulator work at a depth of 10°cm. at 12°C. to 13°C. These radishes may stand closer (500 per sq.m. to 600 per sq.m.) as the leaves will be smaller, but it takes longer for them to mature.

b.

b. Later forcing (under favourable conditions of light in April - May).

1. Radishes grown under glass sown after 1st April need no artificial heating. When the weather is clear and sunny, the temperature may be allowed to rise to 18°c.-20°c. before ventilating, but care should be taken to keep the night temperature rather low. If the temperature during the night does not sink below zero, there is no need to cover the plants with mats in the evening.

2. The plants can also be allowed to stand more densely, up to 600 per sq.m. But in that case care must be taken that the temperature is not too high. If they are sown very densely, the temperature must be kept well down by ventilation, so that the leaves shall not be too large and the formation of the radishes prevented.

c. Air-heating cables for radishes.

Artificial air-heating for radishes should not be used except for extra early forcing (January - February). In places with a wet climate it may be used later. If air-heating cables are used they should not be applied when the air temperature in the bed is above 12°c. If they are coupled to a thermo-regulator this instrument should work at about that temperature.

247. Definite injury has been found to occur in a number of commercial varieties of potatoes stored at low temperature (32°F., 36°F., and to a slight extent at 40°F). One type of damage is marked by a shrivelling or shrinking of the tubers, accompanied by a general breakdown of the tissue, while the other is characterized by darkening or killing of the tissues surrounding the buds and lenticels. The former type is found chiefly among immature potatoes stored at 32°F. within 4 or 5 days after harvesting. The condition becomes noticeable 2 or 3 weeks after the tubers are placed in storage; on removal to a temperature of 70°F. decay ensues, and in the Early Rose variety the symptoms are identical with those of black heart. The second type of injury has been observed in both immature and mature potatoes from 1 to 3 weeks after being placed in storage at 32°F. or 36°F. It was accompanied by a failure of germination, the production of spindle sprouts, and a pitting and browning of the lenticels in most varieties. Preliminary storage for 21 days at 40°F. or 50°F., or for 7 days or longer at 60°F. or 70°F. greatly reduced the incidence of these injuries.

248. *The deterioration in the taste of milk produced by ultra-violet irradiation is caused by the action of hydrogen peroxide on the proteins, and does not run parallel with the activation. The taste of protein-free cream or of animal oils is not affected by prolonged irradiation.

249. *Developing apples and mature apples from different localities and grown in different seasons have been analysed to determine the effect of environmental factors on the composition of the mature fruit.

Analyses

Analyses of developing apples (Bramley's Seedling) showed that growth as measured by weight proceeds at an increasing rate until the last month on the tree, when it is very slow. Most of the nitrogen is accumulated during the 2 months immediately following the setting of the fruit, and this rapid intake of nitrogen is probably associated with the cell division which occurs at the same time. Starch and acid accumulation are found to be closely associated, and both follow the time of maximum nitrogen storage; the synthesis of starch and production of acid thus appear to be closely related in these apples. The rate of accumulation of soluble carbohydrates increases at first, remains constant while starch is being stored, and finally increases rapidly, probably from hydrolysis of starch as well as intake from the tree.

Bramley's Seedling apples from different localities showed very large differences in composition in respect of dry weight, acid and nitrogen. In successive seasons apples from the same orchards also showed variations of dry weight and acid, but these were not so great as when apples from different orchards were compared. Nitrogen content showed no seasonal difference.

It is suggested from consideration of meteorological data for various localities and seasons that when climatic conditions are unfavourable, i.e. low temperature or lack of sunshine and high rainfall, the amount of acid accumulated in the apple is greater and the amount of dry weight and sucrose lower than in more favourable conditions. Cultural conditions and characteristics of the tree (e.g. stock scion) presumably account for the larger differences observed between localities.

250. * The season of 1926 differed completely from those of the earlier experiments, 1922 onwards, in having far less sunshine during the growing season of the barley. This brought out two important properties of the nitrogenous manuring that had not been observed in any of the previous experiments.

(1) The nitrogenous manure in nearly half the experiments gave no increase in crop, indeed there was some evidence at Rothamsted and elsewhere of a harmful effect on yield.

(2) It tended to lower the valuation of the barley and of the malt, especially those of higher price, and to raise the percentage of nitrogen in the barley and lower the 1,000 corn weight. If 1926 were typical it would be necessary to revise the conclusions of the last four reports; it was, however, distinctly abnormal.

251. Far up on the highest mountain slopes and in the frozen north the struggle of trees for life at the timberline has been going on for ages. The most important areas of conflict are in the Arctic, along the Himalayas and the Alps and on the ridges of the Rockies and the Andes. In the mountains of central Colorado the trees make their farthest stand against the elements at about 2 miles above sea-level. Always from the same direction, blowing winter and summer, the wind proves the most relentless foe. Then in winter comes the snow which piles up in great drifts pressing down the limbs under its weight. For 6 months or more the trees are at the mercy of the snows, and when spring comes the battle with the wind by itself begins again.

In

In the Rockies of Colorado the commonest trees to reach the timberline are the limber pines and the Engelmann spruce. In other parts of the Rockies the white bark pine is found well in the van. A few other trees also reach the front line in Colorado, but they are less frequently seen - the quaking aspen, Alpine fir and foxtail fir.

In the far north the timberline comes down to the shores of the Arctic sea just beyond the Circle. From here southward it rises as it nears the Tropics. In the Canadian Rockies the battle-ground of the trees against the elements varies from 5,000 ft. to 6,000 ft. above sea-level. On Mt. Rainier it is 7,000 ft; in Central Colorado 10,000 ft. to 12,000 ft. The highest of these battle-fields is believed to be in Mexico, on Mt. Orizaba, where the hardiest tree is 14,000 ft. above the sea.

252. The author discusses the effects of environmental factors on normal and abnormal growth and development of plants in general. The factors considered in detail are sunlight, temperature, moisture, physical and chemical properties of the soil, and parasitic organisms. As far as possible, the operative mechanism of each factor is explained in terms of physics and chemistry. The treatise covers many phases of pathological conditions and attempts to explain the causes in each case.

253. The average temperature prevalent during the growing season (May, June and July) in the spring wheat area in epidemic years was compared with that for non-epidemic years during the 22-year period 1904 to 1925 inclusive. From the data presented in this paper it is evident that, in the past, there has been a tendency for destructive epidemics to develop in warm growing seasons, and for cool seasons to be comparatively free from rust. The amount of departure from normal also seems to have been correlated with the occurrence of epidemics. It is possible that these tendencies were coincidences, but it seems more reasonable to suppose that they represent a causal relationship and are indicative of the effect of temperature on the development of epidemics.

254. *The term "dry-farming" is applied to the cultural practices in those sections of Canada where crop yields are limited by the amount of available moisture. In view of the pronounced influence of moisture upon the growth of crops in these sections, an attempt has been made to determine the effect which crop rotations and cultural operations have on the loss or storage of moisture in the soil. The two methods of study used at the Dominion Experimental Station, Swift Current, Saskatchewan were in the one case by determining the moisture content of samples taken by the soil auger and soil tube and in the other case by measuring the moisture changes, through variations in weight, of the mass of soil contained in deep tanks. From the results of the first method it is apparent that wide variations are present in the moisture content of the soil even in closely adjoining areas and data have not been obtained accurate enough to correlate crop yields with soil moisture variations.

The

The results of the tank experiments bring out very clearly the intimate relationship between crop yields and moisture supply. The value of the summer fallow is clearly demonstrated. The summer fallow furnishes not only a reserve of soil moisture but it also permits a more efficient utilisation of the total supply. In every case the crop following a summer fallow has been able to use more of the soil moisture than where it directly followed a previous crop. The early ploughing of the summer fallow is considered essential to success.

255. On bright sunny days in the spring the tops of young coniferous trees, appearing but a few feet above the hard snow crust, would be exposed to rather severe climatic conditions with their stems and roots buried under perhaps several feet of cold snow. The snow, however, probably has a warming effect during most of the winter, and keeps the ground from deep freezing, or enables it to thaw out slowly if frozen before the snow came. Snow transmits some solar radiation, and retains heat by the non-conducting air pockets which form a large percentage of the volume of snow. Nevertheless, the soil is doubtless at the freezing-point, and therefore physiologically dry, and the stem of the tree, packed in an ice jacket, is also in a poor condition to supply the transpiration needs of the needles. Any factor which stimulates transpiration under conditions when the water loss cannot be met may be injurious. Temperature caused by strong insolation, low atmospheric pressure, and humidity are some of these.

Measurements of relative humidity were made at Brannberg, Sweden on 27th April, 1924. It was a perfectly clear day with a very light north breeze. The snow crust was dotted with the tops of Scotch pine seedlings just showing above the snow which was 1 m. thick. In no case was the relative humidity low enough to indicate severe drying of tree-tops because of atmospheric dryness. However, the humidity was often surprisingly low when one considers the nearness of the snow surface, which must have been evaporating actively. The lowest humidities were observed with the greatest air movement. It seems probable that most weather injury to trees in winter is caused by violent winds at temperatures below freezing, and the accompanying dryness. With a snow surface nearby, the sun will rarely heat up frozen tissue rapidly enough to cause rupture by rapid thawing, such as occurs in rapidly growing tissue in June. Much more severe conditions are to be met with when there is no protective snow-cover.

256. *The thermal death point of the blow-fly was definitely influenced by the factor of humidity.

Saturated and dry air had the effect of lowering the thermal death-point.

Relative humidities from 60 per cent. to 80 per cent. were more favourable, while relative humidity of 70 per cent. actually was found to be an optimum point.

From the weighings it may be concluded that death in saturated air was due to the inability of the flies to regulate their heat by evaporation.

257. This article deals with the use of climagraphs in ecological studies applying the method worked out by R. Regel, who has established the following groupings of frost-free days with reference to optima for certain physiological processes in plants:

(1) Cold days without frost, the average daily temperature fluctuating from 0.1C. to 4.5°C., in which seeds become active. (2) Cool days without frost, the average daily temperature fluctuating from 4.6°C. to 9.9°C. which induce development of subterranean vegetation, root formation. (3) Mild days with an average daily temperature varying from 10°C. to 14.9°C., which favour normal growth of tops. (4) Warm days with an average daily temperature between 15°C. and 22°C., in which the flowering parts of the plant are developed and fruit is formed. In temperate climates such temperatures retard somewhat the vegetative growth, but at times, when an excess of moisture is present, the vegetative portion may continue to grow to the detriment of fruit formation. (5) Hot days with average temperature higher than 22°C. favouring the maturing of fruit.

Following these groupings the author shows graphically the weather conditions, such as temperature, sunlight, and rainfall, favourable for the growth of barley.

258. Noting in a brief review of the literature marked variation in the reported ability of the legume bacteria to resist drying, the author presents the results of pot experiments at the Washington Experiment Station in the greenhouse and out of doors, in which he finds Rhizobium leguminosarum grown in Palouse silt loam to be capable of surviving exposure to wide extremes of soil moisture without apparent effect upon subsequent nodule production. Soil moisture excessive to the point of saturation or flooding was much more detrimental than extreme dryness approaching the air-dry condition. Extreme summer and winter temperatures appeared to be without injurious effect upon nodule production by legume bacteria in the soil. Legume bacteria for alfalfa, peas, and sweet clover, once inoculated into the semi-arid soils of eastern Washington, readily produced nodules and survived climatic variations for 10 yr. to 15 yr. or more in the absence of the host plant. Distribution by wind and dust-storms was detected, but is not considered sufficient for the thorough inoculation of legumes planted in new fields.

259. From quantitative records accumulated by the State Natural History Survey in its plant disease survey of Illinois, those of three selected diseases - potato late-blight, wheat leaf-rust, and apple bitter-rot, are briefly tabulated and the prevalence and intensity of each correlated with temperature and rainfall by means of climographs.

From Martin's data on late-blight we may construct climographs showing July temperature and rainfall combinations productive of severe blight, light blight, and no blight. Normal July temperature-rainfall combinations for certain localities in the northern and southwestern Illinois potato districts occur outside of the limits for blight. The interpretation that both of the Illinois potato regions have temperature-rainfall combinations not favouring late-blight development is substantiated by field records, blight never having been found in the southwest and only rarely in the north.

Similar

Similar climographs, based upon field data from Illinois, indicate correlations between the intensity of leaf-rust and bitter-rot infection and temperature-rainfall combinations. With adequate field data at hand, this method will measure phenological influences with an accuracy permitting practical use.

260. The author, in his investigations on the cause of the poor corn harvest of 1924 in the Danube districts, attributable either to weather conditions or to vegetable or animal pests, was able to determine the important influence of the relation existing between soil and air temperatures on plant growth and hence on the final crop.

Whereas in practice in good years the soil temperature from the middle of April till the middle of May had been as high or higher than the air temperature, in 1924 it lagged considerably and only caught up for the first time towards the end of May.

In answer to the question how the influence of this temperature relation is important, the author adduces the relationship, which recent work has shown to exist between air nutrition (CO_2 and light) and soil nutrition (Nitrogen, phosphorus, potassium and water), as also the strong influence of the soil generated CO_2. Soil nutrition as opposed to air nutrition induces increased growth of the vegetative organs at the expense of flowers and fruit, while air nutrition induces increased flower formation and better development of fruit. Only when the air nutrition, i.e. particularly the CO_2 nutrition of the plant, does not wait on the soil nutrition factors, can the flowers and fruit develop properly. It is therefore important for CO_2 to be at the disposal of the plant at the proper time, which is in particular the time of flower development and fruit formation.

As is now well known, the CO_2 of the air does not satisfy plant requirements in respect of this food and the CO_2 of the soil has to make good the deficiency; consequently the development of the plant depends to quite an important degree on the production of CO_2 by the soil. CO_2 production is for its part dependent to a high degree on temperature relationships among other factors.

Hence it is very important for the crop that the soil should be fairly quickly dried in early spring, so as to free the top layers from water, which is a bad heat conductor, and replace it with air, which isolates the quickly warming soil layers above it from the still cold layers beneath.

It follows from the above that the proportion of grain to straw is very closely connected with these phenomena. Only therefore in years when soil temperature catches up air temperature early enough in the spring can a satisfactory grain-straw ratio be expected.

The author's conclusions have great practical value in addition to their scientific importance. If they are proved correct, it will be possible to make the manurial and cultural operations suit the temperature relations. Moreover, the relation of air to soil temperature in spring will play an important part in crop forecasting.

261. A report on studies at the University of California in which the percentage of germination and the speed of emergence of the seedlings at constant temperatures of 39.2°F., 46.4°F., 51.8°F., 64.4°F., 77°F., and 86°F., were recorded for 17 species of vegetables.

Speed of germination increased for all species in accordance with rising temperature, but certain cold resistant kinds, namely, spinach, lettuce, cabbage, parsley and beets, gave higher germinations at the lower temperatures, the optimum temperature for spinach being 39.2°F., cabbage 46.4°F., and beet 51.8°F. It is suggested that the rapidity of growth of seedlings may depend on the velocity of the chemical reactions which are responsible for the characteristic metabolism of each kind of germinating seed.

262. This is an abstract of a paper presented at the 20th annual meeting of the American Society of Agricultural Engineers at Lake Tahoe, California, which reported the results of studies conducted at the California Experiment Station on the behaviour of soil moisture as regards its movement in the soil due to capillarity, evaporation from exposed soil surfaces, and the reaction of certain plants to different amounts of soil moisture under California conditions. It is pointed out that the findings are rather sharply at variance with the preponderance of previously existing views on these subjects.

It was found that when soils are not in contact with free water, capillary movement is extremely slow in rate and slight in amount. Cultivation was found to have a negligible influence on the amount of evaporation from clay loam soils packed in tanks. It was noted that the rapid loss of water by evaporation during the first few days following the application of water took place chiefly before the soil was fit to cultivate.

No real differences in soil moisture behaviour between cultivated and uncultivated plots were noted at four different localities representing a wide range of climatic conditions. Furthermore no significant loss of moisture occurred from the soil depth zone of 3 ft. to 6 ft. The losses were confined almost entirely to the surface foot of soil, largely in the upper 8 in. and mostly from the first 4 in. The amount and rapidity of moisture dissipation by moisture transpiration from growing crops were in sharp contrast to the extremely small and slow loss of soil moisture by evaporation.

The belief is expressed that many of the conclusions drawn from studies concerning the water relations of plants grown under supposedly constant soil moisture conditions are erroneous, and that most work of this nature is not free from the doubt that the uniform percentage of soil moisture assumed actually was maintained.

263. Experiments on the rate and depth of penetration and on the distribution of water added to comparatively dry soils are reported. The procedure consisted essentially in filling 4 in. brass tubes 1.5 ft. to 3 ft. long, or, in a few tests, 6 in. and 8 in. iron tubes 4 ft. to 8 ft. long with a suitable soil, followed by the addition at the surface of water sufficient to give an

irrigation

irrigation of the desired depth, a usual head of from 1 in. to 1.5 in. being maintained until all the water had been applied. The tubes were covered with a close, but not air-tight top immediately upon the disappearance of the water from the surface.

From the data obtained with respect to percentage of moisture in each inch of soil in the tubes after various intervals, and from a consideration of plots of these data, it was concluded that soils possess a normal moisture capacity, defined as the minimum amount of water that is retained by absorption and film forces when the water is free to move downward through a mass of uniform soil, which is approximately the same as the moisture equivalent. At the normal moisture capacity the moisture was found readily available for plants, but not free to move under the normal film forces existing in the soil. When the soil moisture is equivalent to this normal moisture capacity it is considered that mulches will be of little or no effect, inasmuch as upward movement to supply evaporation does not occur. It is further pointed out that in deep uniform soil water added by rain or irrigation penetrates the soil rapidly and soon approaches a state of distribution represented by the normal moisture capacity, beyond which the storing up of water in a deep soil by winter irrigation or ordinary application of excessive amounts of water early in the season cannot take place unless the soil lies upon an impervious layer capable of producing a perched water table and a zone of saturation.

264. In the first contribution to the subject from the United States Department of Agricultural Office of Experiment Stations, an attempt is made to throw some light on the available knowledge relating to the forms in which water is present in soils and the factors influencing its absorption and retention.

The likelihood is indicated that moisture does exist in soils in different forms with reference to its activity and availability to plants. Apparently the occurrence of these forms of moisture is governed in some instances and influenced in most by the texture and structure of soils by their physicochemical composition, and by certain external factors such as temperature. The most striking and definite indication from this analytical summary is that the factors determining the existence of soil moisture forms also influence the absorption and retention of moisture by soils. It is pointed out, however, that the state of the available knowledge of these phenomena seems yet so incomplete and disconnected as to leave considerable doubt as to the exact nature and extent of the influences of the factors involved. A bibliography of 45 references is appended.

265. In a second contribution from the United States Department of Agricultural Office of Experiment Stations, an analytical summary of work relating to soil moisture losses and factors in their prevention is presented.

The results appear to indicate that practically the same internal and external factors which influence the manner of occurrence, absorption, and retention of moisture in soils also have some bearing on the nature and extent of the losses of moisture from soils by gravity and evaporation. This seems to be especially indicated by the results of investigations of mulching and cultivation practices. A bibliography of 45 references to literature bearing on the subject is included.

266. This bulletin offers recommendations for the improved management of soils of eastern Washington, which show a very evident depletion after only 40 yr. of cropping under the prevailing system. These recommendations are intended to lay the foundation of a more permanent type of agriculture than is possible under the destructive summer fallow system now in practice. Among the subjects discussed are the following:- Precipitation and its influence; moisture penetration and distribution in the soil; evidence of soil depletion; influence of summer fallow tillage; essentials of good summer fallow; clean summer fallow; effectiveness of June rain on summer fallow; and of June rain on the crop.

267. The author begins with a consideration of area rainfall in Australia; he shows from observations made over a period of years the possibility of ascertaining the frequency distribution of rainfall in any district. He points out that a calculation of the probability of rainfall in excess of a certain minimum in one year followed logically from such data; the use of such calculations made the risks of the pastoral industry ascertainable. Turning to the wheat crop, the author shows that in the curve of annual yields there is a steady rise, due presumably to the introduction of superior methods of cultivation, and that the mean curve can be calculated; from this curve there is an 80 per cent. correlation between August-September precipitation and final yield. Crop estimates based on this method have the great merit of being early. In the season 1926-27 they were within 10 per cent. of the yield finally reported. Rains in October and November have some influence on the yield, but chiefly in increasing grain size and water content. Dealing with the pastoral industry, he shows that grazing capacity per acre is in the western half of the State correlated with rainfall. and that average fleece weight varies in conjunction with that of January and February. In the eastern half of the State, where the rainfall is considerably higher, and in the central district, where hand feeding is frequent, the results are divergent. As regards lambing observations on certain large estates show the existence of a close correlation between the combined precipitation of January and April and production of lambs.

268. A comprehensive review with bibliography of world-wide studies upon the influence of forests upon climate, rainfall, temperature and moisture content of the soil, run-off, and the flow of streams. It is shown that forests tend to equalise the flow of streams throughout the year by making the low stages higher and the high stages lower, but do not necessarily prevent floods although aiding materially in reducing their destructiveness.

269. Increasing the length of light exposure by the use

of

of strong electric lamps stimulated growth and brought into early flowering various species grown both from cuttings and from seed. Light requirements differed with species but were regulated by placing the plants at different distances from the lamps.

270. *1. Seasonal variation in yield is of such magnitude as not to be masked to any appreciable degree by variations caused from year to year by changes in the personnel of the oat varieties that chanced to be grown.

2. There is no correlation between yield and total rainfall or total accumulated temperatures for the whole growing season.

3. Requirement in respect of total accumulated temperature for the growing season is not a fixed characteristic of any variety, but varies with any single variety from year to year.

4. The existence of two critical periods for oats within the growing season, the one for the 20 days after the emergence of the plants in spring, and the other for the 14 days covering the emergence of the panicles, has been shown. The correlation coefficient for (a) rainfall and yield and for (b) accumulated temperatures and yield for these periods have been determined as

(a) For first period:
Gross $r = -0.450 \pm 0.134$.
Net $r = -0.299 \pm 0.153$ for rainfall and yield.

For second period:
Gross $r = +0.870 \pm 0.042$
Net $r = +0.841 \pm 0.051$ for rainfall and yield.

(b) For first period:
Gross $r = +0.447 \pm 0.134$
Net $r = +0.287 \pm 0.189$ for accumulated temperatures and yield.

For second period:
Gross $r = -0.633 \pm 0.104$.
Net $r = -0.523 \pm 0.109$ for accumulated temperatures and yield.

The significance of warm dry conditions after sowing is not as high as the significance of high rainfall and low temperatures for the emergence of the panicles, though, in this area both are concomitant with high yield.

5. The oat plant is essentially a lover of cool, humid conditions in its later life periods. High temperatures, particularly if unaccompanied by precipitation in the later stages of ripening may prove particularly damaging to grain yields.

6. Drought periods, particularly from June onward, are likely to reduce yield, particularly if accompanied by high temperatures for the same period.

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271. The various climatic and vegetation districts of Germany are mapped and described, and discussed in relation to the agricultural use of the land and zones especially suited to certain crops.

272. * This study has shown that there is a close connection between the chances of a single favourable year and the ability of Porosagrotis orthogonia to maintain itself at a place. At least 1 yr. in 10 yr. must be favourable to increase or the insect will disappear. Outbreaks brought on by migrating moths are confined to regions where at least 1 yr. in 20 yr. is favourable.

It has been shown that 4 in. of rainfall during May, June and July is a critical value and that in this respect there is a decided tendency for like years to follow in succession, and this tendency was evaluated, without any implication of periodicity, by forming a distribution curve of interannual differences, neglecting signs. In all cases a decidedly skewed distribution was obtained from which the probability of a deviation of 1 in. or less between successive years was calculated.

Severe attacks of the pale western cutworm may be expected only at long intervals in most parts of its range. In the dry mountain foothills near Helena such outbreaks will be about 16 yr. apart, on the central plains of Montana and in Wyoming it may occur once in 20 yr. to 25 yr., and in eastern Montana and Colorado the average interval between outbreaks is about 30 yr. In other parts of its range in the United States it will probably be more rarely injurious. Light outbreaks may be expected somewhat more frequently.

273. * The apple variety collection of the Bureau of Plant Industry at the Arlington Experiment Farm, Rosslyn, Va., near Washington, D.C., has been employed in a study of the variations in chemical composition of the expressed juices occurring from year to year and the relations borne to such variations by the annual variation in climatic conditions.

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The six years during which the work was in progress presented an exceptionally wide range both in the amounts and distribution of the individual climatic factors and in the combinations of those factors occurring during the growing season at Washington.

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The chemical composition of the crop of a given year, when the results for all varieties are considered collectively, shows a definite relationship to the amount and distribution of the climatic factors during the growing season of that year. These climatic factors exert an effect upon chemical composition which is manifest as modification in like direction and degree of the composition of the fruit of a large number of varieties of widely diverse character and degree of adaptation to locality.

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If the composition of the crop in 1920, a year very closely approximating the normal in climatic conditions, is

used

used as a basis for comparison, the relation of climatic conditions, to chemical composition of apples at Washington is such that increases in amount of sunshine and temperature over the normal amounts result in general increases in sugar content of the fruit over the amount present in the climatically normal year. Decreases in amounts of sunshine and temperature below the normal result in general depression of sugar content of the fruit below the amount present in the climatically normal year. The extent of the departure of sunshine and temperature from the normal amounts is a direct measure of the departure of the composition of the crop from that of the climatically normal year in every year except 1925. In that year, a large deficiency in precipitation operated as a limiting factor upon photosynthesis and altered the degree but not the direction of the response of the crop.

There is a definite and consistent correlation of sugar content, both of total sugar and of sucrose, with acid content and content of astringent substances. The correlation between sugar content and acidity is positive, that between sugar and astringent substances is negative, high sugar content being accompanied by high acidity and low astringency, low sugar content by low acidity and high astringency, and medium sugar content by absence of extremes in amounts of the other two constituents. This general relationship of sugar, acid, and astringent content is consistently presented by masses of varieties. In one year the correlation breaks down as a result of the interference of a limiting factor, shortage of water, with the normal course of physiological processes.

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The climatic conditions conducive to the development of a high content of sugar and acid in the fruit of the apple are also conducive to the reduction to a low level of the content of astringent materials therein. Conversely, the climatic conditions which limit the development of sugar and acid content to a medium or low level are such as increase the formation, or depress the rate of destruction, of astringent substances, thus leaving their amount at a higher level. As a result, absence of extremes, as medium sugar and medium astringency, or opposite extremes, as high sugar and low astringency or the reverse condition, are found together. Like extremes, as low sugar and low astringency are not found together, for the reason that any one set of climatic conditions can not produce both results. In consequence, the acid-astringency-sugar ratio of a given variety will vary quite widely from year to year in a locality having as wide variation in seasonal conditions as Washington, and will have relatively narrow variations in a region having a narrow range of variation in seasonal conditions.

The acid-astringency-sugar ratio, which states the relative amounts of titratable acidity, total sugars, and total astringent substances contained in a fruit juice, presents the results of chemical analysis in a form designed to convey a conception of the beverage quality of the juice. The ratio expresses the relative amounts of the 3 factors upon which the sense of taste bases its estimate of the product. Since beverage quality depends upon the relation rather than the absolute amounts of these substances, a knowledge of the acid-astringency-sugar ratio is more important than a chemical analysis in determining the beverage quality of a juice.

It has now been established that climatic conditions during the growing season exert a determining influence upon

chemical

chemical composition of the annual crop of fruit in the case of two perennial plants, the apple and the grape, and that the character of the effect upon the various constituents of the fruit is identical except for secondary differences due to morphological dissimilarities of the two fruits. Since large groups of dissimilar varieties of the two species exhibit uniformity of response to the annual variations in the factors of the climatic complex, it would appear that the annual crop of fruit upon a perennial plant is an integrated expression of the climatic factors for the season in which it is produced, in the same degree to which the growth of an annual plant integrates those factors.

274. In experiments with 19 different physiological forms of Puccinia graminis tritici isolated from rusted wheat grown under uniform conditions in rust nurseries at 34 centres in the United States and Canada between 1919 and 1923, the writer found that all the forms except two attacked all the hard red spring varieties under greenhouse conditions. Marquis was resistant to one of the two excepted forms and Kota to the other. Two of the physiological forms infected Vernal emmer normally under greenhouse conditions, but Khapli was not appreciably affected in any circumstances. Little Club was completely susceptible to all the forms, and Einkorn moderately so to most of them. Some of the physiological forms isolated were of frequent occurrence and wide distribution, while others were rarely found.

A positive correlation was observed between the average temperature and total rainfall during the last two months of the growing season and the severity of stem rust infection on susceptible varieties. When the total precipitation fell below 2 in. or the temperature was under 60°F., no rust developed. Not more than 40 per cent. of infection (as estimated by the proportion of the leaf surface covered by rust pustules on the scale of the Office of Cereal Diseases, (United States Department of Agriculture) generally occurred at or below 62°F., while over 90 per cent. was observed only where the average temperature ranged from 66°F. to 72°F. and the total rainfall exceeded 2.5 in.

Other factors besides temperature and rainfall were shown to have a preponderating influence on the development of rust epidemics, but the evaluation of these factors requires much further observation and experiment.

The relative parasitism of the various physiological forms was not found to be appreciably affected by external conditions nor by the locality of origin of the different isolations of each form. No evidence was obtained that the several forms arose by progressive adaption to their environment.

275. The results of four years' phenological observations in relation to the injury caused by various insect pests to grain crops sown at different periods from August to October are discussed and tabulated. The duration and intensity of oviposition by the Swedish fly (Oscinella frit, L.) on those crops depend on meteorological conditions in the summer and autumn. A lowered autumn temperature reduces the fertility of the individual flies and is unfavourable to the eggs and larvae. The chief injury is usually caused by the first summer generation, as the second generation seldom develops sufficiently

rapidly

rapidly to infest the crops in the same year, though under exceptional conditions the flies may possibly survive long enough to attack these crops the following year. The second generation is seldom completed in the same year and may sometimes be entirely absent. It is favoured by a warm summer, resulting in an early appearance of the first summer generation followed by intensive egg laying, and by continued warm weather in September. When as in 1924 this second generation is completed, a large number of adults occur in the autumn, augmenting the damage done by the first generation.

The injury done by the gout fly (Chlorops taeniopus, Mg.) in relation to the time of sowing more or less corresponds to that of O. frit.

The Hessian fly (Mayetiola destructor, Say) caused more injury in autumn to rye than to winter wheat, though according to the literature under equal conditions the latter suffers more. During 1924 the rye developed more rapidly than the wheat and was therefore more suitable for attack by M. destructor and other pests in the autumn, but by the spring it had passed the most susceptible stage (2nd leaf phase) whereas the more slowly developing wheat plants appear to be more liable to attack by certain insect pests in the spring. The spring temperature is the determining factor in the emergence of O. frit and C. taeniopus from the cocoons. Other conditions being equal, their emergence will depend on what stage the insect reached before hibernation. While the three pests mentioned, confine their attack in the spring to late developing winter crops, such pests as Hylemyia coarctata, Fall., Oponyza florum, F., Prolasioptera (Lasioptera) cerealis Lind., and flea-beetles in some years appear to cause more injury to the earlier sown ones.

The results of these observations indicate that the time of sowing should be chosen with a view to reducing the autumn infestation by O. frit. In this connection sowings at the end of August appear to be most satisfactory under local conditions and also coincide with general agricultural practices. This is also the most suitable time for sowing in case of a heavy outbreak of C. taeniopus.

276. * The optimum-temperature theory as applied to the development of apples asserts that mean summer temperature is the dominant factor of climate which determines quality in apples. It assumes that apple varieties have such exact adaptations to climatic conditions that any variety can attain its optimum development only at a certain definite mean summer temperature, exhibiting definite physical and chemical departures from normality with consequent lowering of quality when grown at temperatures above or below this optimum.

Ninety-eight varieties of apples belonging to 16 groups having supposed temperature optima from 52°F. to 67°F. inclusive, grown together under uniform controlled conditions at the Arlington Experiment Farm, Rosslyn, Va., near Washington, D.C., under an average mean summer temperature of 64.5°F. have been studied over a period of 6 years. The accumulation of analytical data upon the composition of the fruit has been accompanied by a study of the climatic conditions of the years covered by the work.

As the mean summer temperatures at the Arlington farm very closely approximate the optima for the high temperature groups but very greatly exceed those for the low temperature

groups

groups, the optimum temperature theory would assume that there would be a very decided contrast in the results observed with the two groups. Varieties of the low temperature groups should display marked inability to attain normal chemical composition and dessert quality, while the varieties of high temperature groups should attain a development very close to the optimum for the respective varieties. No such contrast appears in the results.

Mean summer temperature as a separate factor has little influence in determining the composition of the crop. The chemical character of the crops of the low temperature group in the warmest year (1921) and the coldest year (1924) are exactly the opposite of expectation based on the assumption that temperature is the dominant factor in determining composition. Years of closely identical mean summer temperatures show very considerable differences in the chemical character of the crop.

The composition of the fruit of all varieties shows considerable variations from year to year. The direction and extent of these variations are determined by the opportunities for photosynthetic activity afforded by the conditions of the season, and in responding to the seasonal conditions all the varieties, high temperature and low temperature groups alike, behave as a unit. Climatic conditions favouring the attainment of high quality as measured by total sugar, sucrose, acid and astringency content in one group favour the attainment of a like condition in all groups regardless of their supposed temperature adaptations. Conditions which depress quality as measured by these constituents in one group exert a like depressing effect upon all groups.

The series of years covered by the experiment presents an exceptionally wide range in the extremes of seasonal conditions which have occurred therein. Throughout the whole period, all the varieties included in the study have shown a high degree of uniformity in their behaviour. In rate of growth, vigour, and health of tree, fruitfulness, and composition of the fruit there have been no indications that any of them were out of adjustment with the environment.

Varieties of the apple possess much greater capacity for adaptation to varied summer temperature conditions than is assumed by the optimum temperature theory.

277. Considerable damage was done during 1925 and 1926 to cereals, flax and garden plants on the Canadian prairies by several species of cutworms. Euxoa ochrogaster, Gn. (red-backed cutworm) was the dominant species in 1925, but in 1926 it was almost entirely replaced by E. messoria Harr. (dark-sided cutworm), when Polia lorea, Gn., was also common especially on lucerne at Winnipeg. This species, which appears as a partly grown larva as soon as any food is available ceased feeding about the middle of May in 1926, so that it is improbable that it will ever become very destructive to cereal crops. E. messoria was first noticed as very small larvae in the middle of May and continued feeding until about the fourth week in June, so that it is capable of causing severe injury to field and garden crops. With a view to using poison baits at night when feeding occurs, an investigation was undertaken to determine the optimum temperature for feeding.

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The experiments were carried out almost nightly from 13th May to 12th June with over 4,000 larvae of E.messoria which were fed on fresh lucorne stems and leaves. From 16th May till 27th May the largest amounts of food were consumed at temperatures between 34°C. and 39°C. so that the higher the temperature becomes during May the more the cutworms will eat; from 28th May until 9th June the optimum feeding temperatures were 20°C. to 25°C., Most food was consumed between 1st June and 8th June, and although the larvae continued feeding until 27th June, very little was consumed towards the end of the period.

An attempt was also made to determine the time required for poisons in baits to kill the cutworms. The maximum number of deaths occurred on the 4th and 5th days with Paris green and on the 5th and 6th days with calcium arsenate.

278. The studies here reported, which are considered in connection with a 9-page list of references, are given in large part in tabular and chart form.

They have shown that the rate of development of certain insects is directly affected by the degree of temperature and that, for the greatest part of the range of temperatures permitting development, this relation is best expressed by a curve for the velocity of development which takes the form of a straight line.

"Data indicate that the straight line departs from its course near the ends. At the upper end the departure is in the direction which indicates a slowing up of acceleration of development. The opposite condition is observed at the lower end of the curve, but here, in the light of evidence presented by other investigators, it seems probable that the increase in the rate of acceleration is due to factors other than temperature and that the actual temperature effect would be represented by a departure from the straight line in the direction which would represent decrease in the rate of acceleration of development.

"For all points along the straight line part of the velocity curve, a given accumulation of temperature, or thermal increment expressed in day-degrees, will accomplish a constant effect, expressed in growth or development. And, further, that summations of temperatures, to derive the constant, may be made from the zero of the velocity curve.

"The point at which development ceases is near to, but sometimes lower than, the zero of the velocity curve. No definite method of locating this threshold of development is suggested.

"Evidence of development in the work reported here has been lacking from insects reared at temperatures approximating the zero of the velocity curve, but other investigators, working with other material, have found evidence of development at points even below the zero of the curve Development has been found to be accelerated by variations in the daily temperature when compared with constant temperatures of the same apparent value.

"Some

"Some evidence is offered to indicate that the quality of carbon dioxide produced during a developmental period is near a constant, regardless of the temperature at which development takes place, and it is suggested that the departures from the constant may represent basal metabolism not directly associated with developmental processes.

"Data are presented which show that temperatures undergoing a daily variation similar to the normal variation found under outdoor conditions have a greater effect upon rate of development than do constant temperatures from which the same thermal increment is to be computed.

"It is shown in the discussions that the law of van't Hoff and possibly Arrhenius' formula also may be applied to developmental data, but that the graphic interpretation, based upon the straight line curve, furnishes a more convenient method of analysis."

280. Under extreme low temperatures, low soil moisture, due to its retardation of the life processes of plants, is protective during the early stages of exposure, but after killing sets in it progresses rapidly. On soils having higher moisture, killing due to cold sets in earlier but progresses less rapidly. The more active the plants at the time of freezing, the more marked is the protective influence of low soil moisture during early exposure. More plants survive on high than on low moisture soils. Plants on soils containing from 40 per cent. to 50 per cent. of moisture were the last to reach the point of killing.

281. * In endeavouring to ascertain the resources of water which a plant can find in a given situation one must take into account not only rain, snow and hail but also the secondary sources of soil moisture; fogs, dews, underground accumulations and surface deposits. It has been shown that a considerable difference exists between the quantity of water evaporated from the soil and its vegetation and that portion of the total precipitation caught in the surface layers of the soil. This difference is still more accentuated when one takes into account the water contained in the harvests and taken away with them.

In the central region of France there is a surprising difference between the quantity of water which falls during the hot season, June to August, and the quantity of water used up by the vines during the same period. The quantity of water carried to the cultivated land by the secondary sources of soil moisture during the hot season must be far greater than that furnished by rain. The amount of water furnished by underground reserves to the higher layers is very small and practically negligible. Fogs in central France are too infrequent, too light and of too short duration to have a noticeable effect on soil moisture. Dew is a more

considerable

considerable source the importance of which to the agriculture of hot countries has been emphasised by various writers, but the amount of water obtained is far less than the difference which has to be accounted for.

Experiments carried out at the Station of Agricultural Physics and Climatology show that nocturnal aqueous deposits usually called dew can be divided into 1., dew properly so-called, i.e. the deposit of water vapour from the air on a body the temperature of which is below the dew point, and 2, the absorption of water vapour from the air by the soil and vegetation, a phenomenon which is only a particular case of the attraction and fixation of a gas by a solid surface. Though the former is an accidental phenomenon more or less frequent, the latter on the contrary is a regular and customary occurrence. During the day it is more often masked by evaporation but it can be observed almost every night. It begins generally some 2 to 2½ hr. after sunset.

The absorption of water vapour from the air by the surface of the soil and by the vegetation which covers it and its condensation in the interior of the soil are, in the central region of France, the only secondary sources of soil moisture of practical interest. During the hot season they are sufficient to compensate for the deficiency of rainfall and they bring to the surface layers of the soil the moisture indispensable to the continued development of cultivated plants.

282. Marquis wheat, grown in pots and subjected to wilting during the tillering, shooting, heading, and milk stages and receiving normal moisture thereafter, suffered most in grain yields when moisture was withheld in the heading and shooting stages, whereas withholding water in the tillering stage seemed to result in yield increases. Barley, evidently more drought resistant, suffered significantly in yield only when wilted in the heading stage. When plants received insufficient moisture (30 per cent.) and were subsequently watered to the optimum at one of the periods, increased yields were had in all series except in the milk stage. The maximum effect was obtained by moistening in the shooting stage. The critical period appeared to be the time preceding exsertion of the spike.

283. This experiment dealt with stream flow from two mountain watersheds of about 200 acres each, situated in the drainage basin of the Rio Grande in southern Colorado. The forest cover of both watersheds was fairly typical of the region as a whole. Stream flow and the meteorological conditions of both watersheds were recorded continuously from late in 1910 until 1st October, 1926. B.watershed was denuded in 1919-20.

The areas in question, because of their geological origin and present character of soil, absorb water readily

without

without appreciable surface run-off or erosion and therefore represent excellent reservoirs for the storage of the precipitation that is released in greatest abundance when snow melts in the spring. High heads were produced only when the ground had become saturated with snow water. Climatic and topographic conditions being uniform, it is evident that the height of a flood crest must vary inversely with the ability of a particular watershed to absorb and to hold great quantities of water. The absolute height of the flood crest under a given set of conditions is, therefore, an inverse measure of the value of the watershed for storage.

On the other hand, the low stage of stream flow is also an indicator of watershed conditions. At Wagon Wheel Gap, as elsewhere, the great increase in evaporation in the warm weather of summer, together with the demands of vegetation which flourishes on the abundant moisture left by the winter's snow, causes a rapid drying of the superficial soil layers, which is not relieved until the crest of the heat is passed, and vegetation has aged and waned. In most temperate climates, as in the locality of this study, the peak of demand is probably passed in the latter part of August. There is no evidence in this study that the summer demand for moisture was appreciably affected by the removal of the forest cover. Evidently surface drying proceeded in just about the same way with forest or herbaceous vegetation. Stream flow, then, is on the decline until the lessening of surface demands for moisture permits current precipitation to reach the deeper soil and add to the supply which is flowing slowly toward springs. Stream flow in the mid-summer period, in the locality of this study is dependent quite largely on the storage capacity of the watershed. In other localities it may be more or less dependent, as the current precipitation is less, or more, adequate to meet the current demands of evaporation. In other words, the low stage of stream flow reached in later summer is in some degree a further measure of the storage capacity of the watershed, and still more clearly a measure of the need for storage capacity.

The ratio of the high stage of a stream to its low stage, as reached within these general limits of time is, therefore, a direct measure of the need for protection of the watershed as a storage reservoir. This ratio, is measured over a number of years, embodies all of the local climatic and soil factors which affect the régime of streams. The higher the ratio, the more apparent it is that everything possible should be done to lower flood crests by retarding the melting of snow in the spring, or increasing the capacity of the soil to absorb quick accessions of water at any time. The higher the ratio, the more evident it is that either in spring freshets or those following heavy rains at any season, water is running off, often superficially, in a hasty, useless and destructive manner.

The

The ability of any vegetative cover to assist absorption, thereby reducing surface run-off and erosion under nearly all conditions, and the ability of a forest cover in particular to retard snow melting, cannot be seriously questioned. On the other hand, a locality whose soil or climatic conditions are not conducive to extremes of run-off obviously does not have the need of a protecting influence in the same degree as a region or watershed whose streams are not permanent and whose freshets may yet be strong and destructive. In the absence of direct measurements of stream flow, the extent to which erosion of a watershed has occurred may be used as a basis for estimating the liability of great extremes of run-off.

On the watershed denuded in the present study the original ratio of high to low stages was about 12 to 1 and this was increased only to 17 to 1 by denudation. The high stages were made much higher and the low stages were made slightly higher. In other words, though the snow water was made available earlier and in more concentrated volume, the watershed was still capable of absorbing it after denudation and of retaining for discharge throughout the year a greater volume than before, although the amount retained was not increased in proportion to the flood volumes. It is obvious that the storage water could not have been increased even to this extent if these watersheds showed any markedly increased tendency to yield surface run-off after denudation. Any flood excess of water that does not go into the storage reservoir, can have no effect on the low water flow from that reservoir. A further factor tending to reduce the low water flow will be the advance in the time when the maximum storage is attained.

It is therefore proposed that the ratio of high to low stages indicates the liability of failure of the watershed to exercise its full storage function and hence the need for protective influences which will cause that function to be exercised to the fullest possible extent, with the probability that so far as spring storage is increased summer flow will be increased, and will not be appreciably decreased by the growing-season drain of the forest cover.

From the evidence of this study it is estimated that in a locality where the normal ratio of high to low stages is more than 25 to 1 with a moderate protective cover, the probabilities are strong that the low stages would be made still lower by removing that protection.

284. Flowering of Apples and Crop. - Observations show that the main flowering period occurs, in the average of years, from the middle of May to the end of the first week in June - such late flowering seriously shortens the season in which the fruit has time to develop, and accounts, to a considerable extent, for the lack of size, colour, and in the case of dessert sorts, flavour, which characterises north-country fruit generally; nor is there apparently a compensating immunity from unfavourable flowering conditions, as the following records show:-

Year

Year.	Main Flowering Period.	General Weather Conditions.	Crop in Cwt.
1913	21 May - 7 June.	Fair, warm, dry.	10
1914	8 May -25 May.	Changeable; mostly fine and warm.	20¾
1915	22 May - 9 June.	Winds mainly W.; fair and warm.	20½
1916	19 May - 5 June.	Very changeable; moderate temperature.	9⅝
1917	29 May -11 June.	Winds variable; mainly fine and warm.	5⅝
1918	15 May -29 May.	Winds S.W.; very fine and warm.	32⅛
1919	20 May - 4 June.	Winds E.; hot days, cool nights, very dry.	18¾
1920	12 May -28 May.	Winds variable; even temperature, fair.	16¼
1921	6 May -23 May.	Winds mainly W.; variable temperature, dry.	15
1922	22 May - 6 June.	Winds mainly W.S.W.; fine and warm.	31⅞
1923	29 May -12 June.	Winds mainly E.N.E. to N.W.; dull and cold.	2¾
1924	29 May -12 June.	Winds mainly W. to E.N.E.; wet and cold.	10
1925	27 May -10 June.	Winds mainly W. to E.N.E.; fair and cool.	4
1926	15 May - 1 June.	Winds mainly at first E. then W.S.W.	8
1927	24 May - 7 June.	Winds N.E.; fine, dry and cold.	2½

285. *The serious disease of cotton caused by Bacterium malvacearum E.F.S. is associated with unfavourable climatic conditions.

A description of an apparatus for controlling air temperature and humidity within a chamber is given.

At humidities above 80 per cent. relative humidity the limiting temperature for attack by B. malvacearum was 32°C, above which infection did not occur.

At 70 per cent. relative humidity infection was slight at 25°C.

At lower humidities no infection was obtained at a temperature of 28°C.

286. Zululand comprises three main regions, the lowlands, midlands and highlands, rainfall being greatest on the coastal lowlands and decreasing as the altitude increases inland; a large proportion of the total rainfall occurs in the wet season (October to March) inland. The highlands are free from bush growth and consequently not suitable for Glossina, which is confined to the wooded midlands and lowlands.

Charts are given showing the relation of the monthly

rainfall

rainfall to the occurrence of nagana (trypanosomiasis) of cattle, and it is seen that, although cattle may be bitten by Glossina, in the wet season, the disease is most prevalent during the dry season (April to September), when temperature and humidity are at their minimum and the nutritive value of pasture is poor, and it quickly disappears after the beginning of the spring rains.

287. *This paper reports studies of the germination of different varieties of wheat, soybeans and oats. Samples of each variety were obtained from various agricultural experiment stations and germinated on plaster of Paris blocks at 5 constant temperatures: 10°C., 15°C., 20°C., 25°C. and 30°C.

A temperature of 15°C. was optimum for the germination of the three varieties of wheat. Each wheat variety showed decreased percentage of germination with each temperature above 15°C., with the poorest performance at 30°C. Mould attack on germinating wheat increased in direct ratio to the germinating temperature. It is suggested that a temperature of 30°C. affects the protoplast of the wheat kernel in a manner which permits the outward leaching of soluble food materials which are readily attacked by ever present fungi.

Soybeans of good quality germinated approximately as well at the low temperatures as at the high temperatures, but it appeared that 25°C. was the optimum. Apparently mould attack on the germinating soybean had no relation to the temperature because the temperatures used were not high enough to weaken the seed. Undoubtedly, the maximum germination temperature for the soybean is higher than for wheat.

Oats gave practically the same percentage of germination at each of the 5 temperatures. It is probable that oats will germinate satisfactorily at much higher temperatures than wheat. It appeared that 25°C. and 30°C. are equally suited to oat germination. As with soybeans, fungal attack on oats was of little importance at the temperatures used.

288. According to Geinitz, 65 per cent of the yearly precipitation of Mecklenburg is accounted for by plant transpiration, and use, while Halbfass computed that in Sachsen-Weimar only 54 per cent of the precipitation is thus accounted for. From data for both these 2 places it is estimated that about half of the precipitation of northern and central Germany is used by vegetation.

289. *Environmental factors as they affect the production of pistillate and staminate flowers on cucumber plants were studied.

An abundance of light tends to increase the number of staminate flowers, within certain limits.

The reduction of light materially increases the number of pistillate flowers and decreases the number of staminate flowers.

The use of electric light at an intensity of 100 foot-

candles

candles has a marked effect in increasing the number of staminate flowers during days of minimum sunlight.

The presence of fruit exerts an inhibitory effect on the development of the plant as well as on the production of pistillate flowers.

Certain selections having a heavy production of pistillate flowers at the nodes of the main stem show an absence of staminate flowers. These selections under reduced light conditions produce false parthenocarpic fruits when pollination is not accomplished, and even when it is accomplished many of the fruits are not fertilised.

290. Data collected from 390 observers are summarised for each of 9 areas in Bavaria, Prussia, Baden, Wurtemberg, etc., and for each of 4 varieties. The data include date of shooting, date of blossoming, duration of blossoming and beginning of ripening. The following are average figures for each of the 4 varieties.

	Sylvan.	Riesling.	Elbing.	Portuguese.
Date of shooting	25th April	26th April	28th April	24th April
" " blossoming	18th June	17th June	19th June	17th June
Duration of blossoming	8 days	8 days	7 days	6 days
Period from shooting to blossoming	53 "	51 "	51 "	53 "
Period from shooting to beginning of ripening	126 "	129 "	126 "	120 "

291. *A graphical comparison of the spring forest fire records for central Massachusetts during 1927 with the weather records for the same period indicates that the maximum forest fire hazard exists between rainy periods, when the relative humidity is 40 per cent, or less, or when the depression of the dew point is greater than 14°F. Under such conditions, the vapour pressure is generally low, the leaf litter in fully exposed areas contains less than 10 per cent. of moisture at the surface and less than 20 per cent. of moisture at 1 in. depth.

292. *This report presents the results of preliminary experiments designed to determine the conditions most favourable to tomato mildew or leaf mould (Cladosporium fulvum). Each month during 1927 10 plants were inoculated with a suspension of spores in water and placed in a glasshouse either at once or after a period in a moist chamber and the average number of days between inoculation and sporulation was noted.

The disease progressed most rapidly and was most severe in July and August, when the mean temperature of the glasshouse was 74°F. and the frequent rainfall resulted in a high relative humidity which was above 70 per cent. during the day and approached saturation at night. From February to August the accelerated development of the disease was very

noticeable

noticeable. In addition, the results showed that exposure to humid conditions for a period following inoculation favoured the disease far more in spring than in summer. In late autumn and in winter hanging drop cultures showed that the conditions did not inhibit spore germination but it is probable that the prevailing temperatures retarded the development and sporulation of the parasite.

In controlled experiments the disease developed very rapidly at 74°F. to 81°F. in a saturated atmosphere whilst at 50°F. to 55°F. it was scarcely noticeable after 3 weeks. The spores of C.fulvum germinate in water at 38°F. and would in all probability infest the plants at 50°F. to 55°F. and it appears that the effect of low temperature is to check the subsequent development and sporulation of the fungus. On the other hand hot, moist conditions favour the disease.

293. Owing to the extensive injury by the Hessian fly (Mayotiola destructor, Say) to grain crops in 1923, which in some areas amounted to nearly 4,000 acres, it was decided to ascertain the latest safe dates for sowing. For this purpose the Government was divided into the north, south and central areas, the earliest dates recommended being 30th August in the north and 8th September in the south. These recommendations were followed with a few exceptions, and the results proved the value of this method in the control of M. destructor. The average infestation of the winter crops amounted to 1.8 per cent.

294. This experiment, commenced in 1926, was designed to ascertain (1) if the earliness of the crop is affected by the time of applying the first real watering "ball watering" in the early stages being disregarded and (2) if heavier crops can be obtained by increasing the quantity of water given at each watering. The water was applied through a 1-inch hose, which delivered 25 gall. of water per min. In normal watering the hose was used for 8 min. per plot during the early part of the season, the quantity of water applied being at the rate of 29,000 gall. per acre.

In plots 1 and 6, the first watering was applied just before the opening of the 3rd truss. 10 days later, when the rest of the house was watered, most of the flowers on the 3rd truss had set and the 4th truss was opening. In 1926, no appreciable difference was observed between the crops submitted to the different treatments, but actually fruit was picked 6 days earlier from the first watered plots than from the remainder of the house.

For 1927, the soil in this house was sterilised by means of steam, using the harrow system, and, as might be expected, the crop was increased from 32.81 tons per acre in 1926 to 48.4 tons per acre in 1927.

It was intended to repeat the experiments of the previous season, but unfortunately the weather conditions

about

about the time the third truss was opening suddenly became so hot and bright that it was necessary to water the entire house, and therefore the first plots, 1 and 6, were watered only 7 days earlier than the rest of the house. As might be expected, the hastened ripening from these plots observed in 1926 was not so marked in 1927.

A table shows that the increase in quantity of water given from normal to 50 per cent. and 100 per cent. more, shewed results slightly in favour of the heavier applications, whereas, in 1926, no effect was noticeable. This is no doubt due to the fact that steaming the soil so improved root development that the plants were able to make use of the additional water supplied.

The experiment has been valuable in so far as it confirms the idea that the first essential of a successful crop is the development of a luxuriant root system, and that, failing this, the application of increased waterings is no advantage.

The experiment has also been instructive in pointing the direction which future investigation should follow, because observation during its course has indicated that, while the quantity of water supplied is of importance, the method of watering is still more so. Present methods are wasteful, because so much of the water applied merely runs through the soil and does not stay long enough to produce that uniformity of soil moisture which is so important for healthy plant growth. An experiment has been devised for 1928 in which the merits of different methods of watering will be compared. The conclusions, deduced from the past watering experiments, are that under normal conditions watering should commence after the 2nd truss has set, and the quantity should be regulated by the condition of the plant roots. It is suggested that plants with vigorous roots in well drained soil should be given some 40,000 gall. of water per acre per week during April and May, and twice that amount during June to September. It must, however, be remembered that watering is one of the most important tasks connected with nursery work, and that while experiments may explain the fundamental features of this work, they can never convert it into a rule of thumb method, because so much must depend upon the condition of the plant and the nature of its environment. The present experiments will succeed if they lead to a reliable method of watering which will ensure uniformity of soil moisture.

295. A brief account is given of the writer's experiments in the irradiation, by Röntgen rays of varying wave-lengths, of tumours produced on Pelargonium zonale by inoculation with Bacterium tumefaciens. It was shown that irradiation with rays of medium wave-length (KV120, 2mm. Al filter, 0.12, 4.5ED) was more prompt and efficacious in causing arrest of growth and desiccation of the tumour than that with longer ones which did not always effect complete involution. The latter process was accompanied in favourable cases by a resumption of vegetative activity in the affected plant, and by the cicatrization of the injured area.

296. It is very well known that the yields of crops are profoundly influenced by the character of the season. The exact extent of this influence as measured in the yield of wheat per acre is, however, not so well known, especially as the character of the soil and the prevalence of weeds vary considerably from place to place on average farms. The Dominion Experimental Farm System, however, has collected information from its experiments on crop rotations which gives, over a long period of years, the yields of crops grown on the same kind of soil and in the same manner and where differences in yield are due almost entirely to differences in the season. The chief factor affecting crop yields in the prairie provinces is precipitation; when this is abundant and comes at the right time and when proper farming methods are followed, crop yields, unless affected by rust, frost or insect pests, are usually satisfactory.

Over a period of 15 yr. the differences from year to year in the yield of wheat at the Dominion Experimental Stations in Alberta, Saskatchewan and Manitoba have been due practically entirely to differences in precipitation. When it is considered that 96 per sent. of all the cropped land in these 3 provinces is laid down to grain, it will be realised that adverse climatic conditions profoundly affect the production and prosperity of this region.

It is very advisable to handle the land properly not only so as to avoid complete failure in bad years but in order to take full advantage of favourable seasons when these occur. Early and thorough working of the summer fallow and proper methods of handling the stubble land so as to control weeds and conserve moisture are of the most fundamental importance.

297. This small book deals in a most interesting manner with the plant life of central Europe, and gives an extremely good idea of the modern tendencies of geographical botany. The environmental factors are concisely analysed, and their effects on the vegetation and flora are adequately illustrated by specific examples. The vegetation is described under the 3 main headings: forest, forest-free areas, and waters (fresh and sea). The geological history of the flora is summarised with special reference to the Glacial and post-Glacial periods. 11 plates, of 21 excellently selected photographs, accompany the text, which is further illustrated by 64 black and white figures. These last include many outline distributional maps of very clear design References to literature are given at the ends of the chapters and as footnotes, and an index is provided. The work has a wider scope and a more general interest than is indicated by its title.

298. This book is based on studies at field stations of the Bavarian weather service, on what is termed microclimatology, that is, detailed study by very refined methods of the layer of air lying below the level (1.5 m. or more) at which meteorological observations are ordinarily made. The conditions in this layer of air are considered to be those most intimately affecting plant growth and constitute what is termed plant

climate

climate. The subjects dealt with are physics of the layer including temperature variation at different times of the day and night, humidity and wind movement, orographic and plant relations and relations to injurious frosts. A bibliography of 267 references is given. This extensive bibliography and the exhaustive treatment of the subject, especially that part relating to plant climatology, make the book of particular interest to agriculturists, foresters and botanists, as well as to climatologists.

299.* Analysis of soil samples coming from a wide climatic range shows that the total nitrogen content of the soil decreases in the United States from north to south in relation to temperature.

The change of the nitrogen content with temperature is a negative exponential function, provided the rainfall-evaporation ratios are constant. For every 10°C. fall in mean annual temperature, the average nitrogen content of the soil increases 2 to 3 times.

Practical aspects of the investigation, such as the maintenance and the increase of organic matter and nitrogen in the soil, are discussed. It seems to be possible to build up the nitrogen content of the soil by adding organic material in the north, because the low annual temperature would favour its preservation. In the south, however, it will be rather difficult if not impossible to increase permanently the nitrogen content by common green manuring practices, because the high temperature militates against nitrogen accumulation by favouring decomposition.

300. Temperature has a very marked effect on the growth of plants especially if the values for maxima or minima are markedly different from the average. The month of December 1927 furnishes good evidence of the effect on cereals of heavy frosts. During the frost which covered the whole of France from the 16th to the 20th December, 1927, temperature minima reached -4°C. and -70°C. in the Mediterranean region, -6°C. and -10°C. in Brittany and the south-west and -11°C. and -14°C. in the centre and Parisian region and between -15°C. and -20°C. to the north and east. These temperatures were taken in the screen, and for thermometers placed in the open air a little above the soil, i.e. in conditions identical with those experienced by the plants, the readings were from 2°C. to 5°C. lower. Thus on the 18th December, 1927, which was in general the coldest day of the period, there was recorded in the screen and above the soil at Paris -10.2°C. and -13.6°C. respectively, at Tours -10.6°C. and -13.7°C. at Mont Valerien -11.9°C. and -14°C. and at Galluis -13.0°C. and -17.5°C. The National Meteorological Office carried out an enquiry through its meteorological stations and also through the Departmental Meteorological Commissions as to the approximate percentages of wheat and oats destroyed by these frosts in each Department. Temperatures and percentage losses were mapped and the following conclusions were drawn:-

(1) that everywhere in France where screen temperature was not below -9°C., the damage caused to wheat was in general nil or insignificant. The same held good where, although the temperature was below this, the soil was covered with snow.

(2)

(2) In the majority of districts where the screen temperature was below -9°C. and where the soil was not covered with snow a part of the winter sown cereals was destroyed by frosts.

The greatest damage in the case of wheat was a loss of from 1/6th to 1/3rd. In the case of oats from ½ to the total had to be resown. There were important losses of oats in certain districts in the north-east in which wheat did not suffer at all or only very little. Apart from purely agricultural reasons, e.g. choice of varieties, quality of seeds, nature of soils it is interesting to examine the meteorological circumstances causing the losses due to frosts. It seems that the following atmospheric phenomena other than the absence of a snow covering were responsible:-

(a) The thaw was extremely rapid. In 48 hr, there were differences of 15°C. in temperature maxima.

(b) The thaw was accompanied by heavy rainfall lasting the whole of January in the west and centre of France. The rainfall was on the contrary deficient for this month in those parts of the north-west, the north and the north-east, where wheat suffered least.

(c) The excessive humidity of the summer of 1927 having in a number of places delayed field work, wheat sowings were often not carried out until November. A large number of correspondents said that wheat sown in October did not generally suffer like that sown during certain periods in November and particularly during the first 20 days of the month. In 15 farms in the district of Vitre of 80 hectares of wheat, 30 hectares were destroyed, principally among those sown from the 5th to the 25th November.

A similar conclusion was drawn from an examination of 40 farms in the neighbourhood of Tours. All of the wheat sown in October was a success; of that sown from the 1st to the 20th November, 60 per cent. was destroyed. That sown between the 20th November and the beginning of the frosts succeeded to the extent of 33 per cent. but the remainder was not destroyed. These facts are easily explained. It is known that development of wheat is impossible if the average temperature does not reach 6°C. Further, each of the phases of vegetation of this cereal requires a certain number of degrees of warmth in which days when the average temperature does not reach 6°C. cannot be reckoned. In a general way, one can say that in the districts in the north-west of France, according to the humidity, from 60 degrees to 120 degrees of warmth are necessary for the emergence of wheat sown at 3 cm. depth and a further 100 degrees of warmth for the formation of each new leaf. Now in 1927, wheat sown in Ille-et-Vilaine from 15th October to 4th November received before the December frosts a quantity of warmth varying from 400 degrees to 140 degrees, i.e. quite sufficient for brairding and even in the case of the first sowings to form 2 or 3 leaves and some new roots, thanks to which they were able to resist pressure caused by the movement of the frozen earth. Those sown from the 5th to the 25th November received quantities of warmth varying from 140 degrees to 160 degrees, which allowed them to braird, but did not give them sufficient strength to resist the cold. They were, therefore, destroyed. Those sown after the 25th November received a quantity of warmth below 60 degrees,

insufficient

insufficient for their emergence. They were accordingly not destroyed. The same thing happened at Tours where wheat sown from 15th October to 1st November had 345 degrees to 140 degrees of warmth. Those sown from the 2nd to the 20th November had from 140 degrees to 50 degrees and those sown after the 20th November received quantities below 50 degrees. Those sown in November before the 20th were especially tested. It must finally be remarked that the indigenous varieties, in particular Alsace Red, were in general most resistant to frost, and it is doubtless the high proportion of these varieties in some departments of the north and north-east of France which explains why, in spite of the heavy frosts, and the absence of snow, these districts appear to have been very little tested.

One can summarise as follows:-

(1) That a temperature which for several days is below -9°C. in the screen, i.e. below -12°C. to -13°C. near the soil, is dangerous to wheat if the soil is not covered with snow.

(2) That snow protects wheat even when temperature is as low as -20°C. thus justifying once more the well known proverb that the ground welcomes the snow as the old man his cloak.

(3) That one must always remember the old dictum that when sowings after All Saints Day succeed, the father should not pass the tradition on to the son. Evidently this rule cannot be applied absolutely since late sowings are one of the best methods of combatting rust. Wheat should be given the best possible conditions to enable it to resist the December cold which for some years has been the only period of rigorous frost in mild winters.

The above study should be completed by an enquiry carried out from the purely agricultural side to ascertain the different varieties of wheat which suffered least in the different districts from frosts, the effect of the physical condition of the soil and of the cultivations it had received, the effect of manures on the degree of resistance of cereals to cold, and the part played by humidity.

301. The summer and autumn of 1927 were very rainy. Crops of beet and potatoes were lifted very late. Cultivations for wheat were in consequence carried out much later than usual. Sowing were later by at least 3 weeks or a month, except those following lucerne and clover, which were carried out in the month of October. The month of November was less rainy, but the ground remained very wet because the weather was more or less overcast and the temperature cold, of at least fresh. Harassed agriculturists nevertheless sowed what they could in the first and the second fortnights of the month of November. The first fortnight of December was characterised by a low temperature in the neighbourhood of 0°C. or somewhat above. There was little rain and insolation was very weak. The beginning of the second fortnight in December was very cold and at the end of the month from the 27th to the 31st the temperature again went below 0°C. The wheat destroyed (without

distinction

distinction of variety) was that sown after the 15th November and even earlier in certain districts. This was because the frosts took the plants in the milk stage when germination had commenced, the action of the diastases was proceeding and the reserve materials had been liquified. Wheat sown in the first fortnight of December did not germinate owing to unfavourable conditions. It was not, therefore, touched by the frost. It generally germinated in the month of January and did well without distinction of variety. Wheat sown before the second fortnight of November was very unequal. October sown wheat was generally good without distinction of variety. The earlier wheat was sown the more even was the crop. Wheat sown in the first fortnight of November was more or less resistant according to variety. The most resistant wheats were the indigenous ones. This fact is easily comprehensible. The least resistant wheats were the alternative varieties. Between the two were the autumn varieties whose resistance varied according to earliness. No general rule on this point could be laid down. One could conclude that the effect of varieties was only felt when sowings were made before the 15th November, since those sown in the second fortnight of November were generally destroyed. We have seen that wheat sown in October resisted the frosts because it was sown early, but well developed plants resisted the cold very unequally. Following lucerne on uncompressed land, the crop was very unequal because many seeds were lost, and the roots of the young plants suffered at the time of intense cold. Where the land was compressed whether by the passage of tractors or ploughs or rolled, wheat was in general good. As regards the effect of manure, frost was less harmful to wheat sown before the 15th November when manured than when unmanured. When wheat suffered from cold and nitrate of soda was applied early the crop recovered rapidly. Land in bad heart (notably that in which lime was lacking) suffered more from frosts than normal land.

302. * Temperature has been shown to influence the development of the seedling blight of wheat and corn. The wheat seedlings blight in a warm soil and do not blight in a cold soil. The corn seedlings blight in a cold soil and do not blight in a warm soil. The cortical invasion and rotting was found to be due largely to an unbalanced metabolism within the seedling during the early stages of germination which resulted in the cell walls of the protective tissues being composed of intermediate, pectin-like, substances instead of cellulose well reinforced with lignin in wheat or suberin in corn. These walls were easily hydrolyzed which resulted in rapid invasion by the parasite.

The unfavourable environment was used in selecting resistant strains. Selecting for resistance in segregating inbred lines of corn grown in cold soils infested with the parasite has resulted in resistant lines growing well at low temperatures. The further study of these lines in contrast with susceptible lines has shown that the inheritable resistance is similar in nature to the induced resistance brought about by high soil temperatures. Resistance appears to be due to an intensification and stabilization of factors

controlling

controlling a balanced seedling metabolism. This results in cellulose walls well reinforced with suberin and a cell composition unsuitable for the nutrition of the parasite over a wide range of unfavourable environmental conditions.

303. It is suggested that in quantitative studies on temperature effects care should always be used to determine whether an equilibrium as well as a rate effect is conceivably involved and, if so, that the experiments should be carried out in such a manner that the two factors can, as far as possible, be separated.

304. * Corn plants were treated experimentally in such a manner as to simulate the injury of hail. A light treatment inflicted at the time the tassels were just emerging reduced the yield of grain only 2.7 bus. per acre. A week later when the plants were in tassel and ear-shoots, but no silks were showing, an artificial hail treatment of the same severity reduced the yield 9.9 bus. per acre.

The severe hail storm, represented in this experiment by jerking off the blades, was very destructive to corn yields, especially when it occurred at the early silk stage of the plant. Applications of this same treatment at later periods in the growth of the corn plant produced a less damaging effect, and the reduction in yield was progressively less as the treatment was administered later in the plant's development.

305. In the pig feeding tests at the Iowa Experiment Station one of the important observations made was the effect of sunlight on nutrition. Those pigs that were fed out in the open so that they got plenty of sunlight made about the same daily gain as the ones fed inside. But they did it more economically and on less feed.

The pigs fed inside required an average of 425 lb. of feed for each 100 lb. gain to reach a weight of 225 lb. while those fed out in the sunlight reached the same weight with only 391 lb. of feed for each hundred pounds increased weight. The pigs fed outside made 4s. 2d. more per head over and above feed costs than did those fed inside.

It is presumed that sunshine was responsible for the difference because of the fact that the pigs fed outside did not do nearly so well during the early part of the feeding season when the days were short and cold.

Later

Later, however, after the days became longer and more mild, there was a marked improvement in their gains.

306. Observations are recorded for the 3 years from 39 recorders. The observations on 44 plants, shrubs and trees are:- the dates of unfolding of leaves (first normal upper surface of leaf visible); when first blossoms are open; when first normal fruits are ripe; general leaf discoloration (over half the leaves discoloured); and, on cereals, potatoes and flax the observations are:- the dates of sowing, first ears, and harvest.

307. Utilisation of coefficients of correlation for predicting crop production is discussed, experiments relating to the influence of critical periods upon the harvest are cited, and the forecast of the vine harvest at Montpelier is considered. It is by the reasonable interpretation of different data, made by qualified persons, and not by the application of more or less complicated mathematical formulae, that a crop forecast is to be made.

308. The chlorophyll content of Digitaria eriantha, Eragrostis superba, Tragus racemosus, and Themeda triandra, as determined by the method of Willstatter and Stoll is not constant throughout the year, but, from a high initial value in young leaves, decreases during drought periods and increases after rains. Even during periods of 24 hr. the chlorophyll content decreases from early morning to mid-day, and increases again during the ensuing night. Decrease and increase depend on the meteorological factors of the moment, so that on rainy days the difference is within a few per cent. while on extremely dry and sunny days it may extend to 30 per cent. Other factors besides soil moisture influence chlorophyll content. Values in 1923-24 are higher than those in 1924-25, probably due to the higher nocturnal temperature in the former year, though other factors may play a role. Compared with the available European data for grasses, the values of the Bechuanaland grasses are higher for 1923-24, and the same or rather lower for 1924-25.

309. * The importance of the weather as natural control of the cotton boll weevil was apparent soon after its appearance in the United States and the Weather Bureau indicates in its weekly summaries whether the prevailing weather has been favourable or unfavourable for boll weevil activity; also the probable effect of low winter temperatures on those in hibernation.

There

There are three distinct periods of weather influence: (1) the prevailing conditions during the year; (2) the weather during the winter immediately preceding and (3) that for the preceding summer as influencing the number of weevils going into hibernation. In the first and third cases moisture is much the more important and in the second low temperatures as related to mortality of the insects in hibernation. The summer relative humidity is especially significant. If it is hot with the atmosphere dry, favouring rapid evaporation of moisture the larvae may die from intense heat, or their food supply be dried up; the percentage of emergence thus being reduced. On the other hand, moist, cloudy, rainy weather favours a rapid increase in numbers through the growing season.

310.* Citrus fruit pests in California occur in more or less well defined areas. Some species are most destructive under the cooler temperatures near the ocean. Other species are destructive only where the summer weather is hot and dry, There are intermediate types. The distribution of these pests in 1927 is compared with that of 1907. An attempt has been made to designate the maximum temperatures and the minimum humidities which appear to limit the destructiveness of the more important citrus pests.

311. Full-grown cabbage plants removed from the field to a greenhouse in the early autumn of 1925 and held at relatively high temperature failed to go to seed, although still living in December, 1927. Comparable plants taken from the field at the same time and held in a cool house or subjected to low temperature before being placed in the warm greenhouse blossomed in a normal manner.

312. The formulae of Van't Hoff and Arrhenius, which fit. chemical and physical reactions, can not be used to express the effect of temperature on biological reactions, owing to the complex nature of protoplasm. The author presents evidence that biological reactions follow the equation $y = a/x^b$, where x represents temperature and y the time, and a and b are constants. Expressed logarithmically it is $\log y = \log a - b \log x$.

313.* Various experiments made at the Agricultural Academy at Cluj (Roumania) under different cultural systems applied to Banat wheat show that the conditions of growth, modifying the development of the kernel and the manner in which various constituents are laid down, influence kernel texture, hardness and protain content somewhat independently. From these experiments the following observations were made:-

1. The physical properties of wheat grains vary greatly with differences in cultural conditions, but this variation takes place within the limits imposed by the characteristics of the different varieties.

2. For the same variety of Banat wheat, under uniform conditions of growth, if the space factor of vegetation becomes smaller, through an increase in the amount of seed per unit area, the weight per unit volume of the grains increases, and the weight of 1,000 grains diminishes.

3. For Ulca and Arnaut spring wheats the grain texture and the weight of 1,000 grains varies as a function of the moisture content of the soil. The hardness of the grains of Arnaut wheat varies very slightly, but in the same sense, up to a certain limit with the variation in moisture content of the soil. On the contrary with Ulca wheat the grain hardness varies in the opposite sense as the moisture content of the soil. In both wheats, the weight of 1,000 grains varied in the same sense as the moisture content of the soil.

4. For Ulca wheat the degree of hardness of the grain varied in the same sense as the extension of the period of drought during the growth of the plant. The vitreous texture of the grain was more strongly influenced when the drought took place during the last stage of growth.

314.* 1. In the first part of the paper we have shown that when a soil is cropped with cotton or juar at Nagpur, nitrification is only active during the rains and mainly, in the early part of the rains. The maximum accumulation of nitrate, however, takes place too early in the growth of the plant to be of much use to it. The subsequent heavy rains wash out large amounts of nitrate from the soil into the subsoil out of reach of the plant, so that at first sight nitrification is a wasteful process inasmuch as only a small amount of the nitrate produced is of use to the crop. Later in the stage of growth of the cotton or juar there is a shortage of nitrate in the soil as the rain has washed out the nitrate and the presence of the crop prevents efficient cultivation which might encourage nitrification. The cotton crop remains on the land till December and the juar crop till mid-November and hence prevent early cold weather cultivation. It seems that only during the rains does nitrification normally take place in the Central Provinces soils which are under cotton or juar sown in the rains. If, however, the land is cropped with a cold weather crop e.g. linseed, gram or wheat, it received efficient cultivation at the close of the rains and then such soil accumulates large amounts of nitrates in the surface 6 in. and a lesser quantity in the next 6 in. Thus, in the case of land which is cropped with cold weather crops we get nitrification at 2 periods, firstly early in the rains and secondly during the cultivation of the land immediately after the close of the rains and preparatory to sowing in November. We have not so far been able to undertake a study of the effect of interculture on nitrification, but it would appear that efficient hoeing between the rows of cotton or juar whenever possible during the rains and at the end of the rains should prove of great benefit to the crop by increasing the nitrate supplies available to the plant. Unfortunately, weather conditions frequently make this difficult and if the land is left too late the surface dries out and then cannot be efficiently cultivated.

2. On the black cotton soil at Nagpur it appears that the soil undergoes an annual loss of nitrate equivalent to approximately 160 lb. of nitrogen. This means that the surface soil would be completely depleted of nitrogen in less than 50 yr. Actually, it is shown that the nitrogen content of the soil has suffered no loss during the past 25 yr. It seems obvious, therefore, that the loss of nitrogen as nitrate is counterbalanced by the fixation of free nitrogen from the air.

x x x

The results indicate that efficient cultivation at the close of the rains provides sufficient nitrates for a more extended growth of cold weather crops.

315. 2 metabolism trials, 1 each in June and in September were conducted; 3 Holstein cows were used in each trial. The June trial lasted 6 weeks - 3 weeks out of sunlight followed by 3 weeks' exposure to direct sunlight (daily average 5.3 hr.) The ration was the same for the sunlight and non-sunlight periods and consisted of corn silage, fresh lawn clippings and 1 lb. of grain mixture for 3 lb. of milk produced. The grain mixture consisted of corn, wheat bran and oil meal plus NaCl. This ration contains on the air dried basis only about 0.60 per cent. CaO. During the September trial the cows were 4 weeks in direct sunlight (average daily exposure 3.7 hr.) and 4 weeks out of sunlight, the ration being similar in every respect to the one fed in June except that Timothy replaced lawn clippings; also, 28 gm. of marl was added to the ration to make the lime intake in both rations equal. While the negative balances were somewhat reduced in sunlight, consideration of all the data indicates that with the rations used, insufficient lime was assimilated to meet the needs of maintenance and milk production - even in sunlight - with cows producing over 35 lb. of milk per day.

316. The stimulative effect of light of different wave-lengths but of equal energy value upon the germination of seed of Lythrum salacaria and Nicotiana tabacum is proportional to the wave-length, if one considers the light actually passing through the coat and reaching the seed contents. The various wave-lengths were obtained by dispersing a cold light source with a prism and dimming the various wave lengths to equal energy value. Lythrum seed were soaked 12 hr. and then exposed to light of 0.0000225 cal. per sec. per cm^2 of various wave-lengths. The germination time was 36 hr. at 30.5°C. Nicotiana seed were similarly exposed but the soaking time was 24 hr. and the germination period 60 hr. Considerably longer periods of exposure to light gave about equal germination percentages in all wave-lengths. The maximum absorption of light by the seed coats was in the region of 510 $\mu\mu$. In this general region the stimulation of germination fell below that expected if the effect were proportional to the wave length of the rays striking the outside of the seed. This deviation is accounted for by the greater absorption of the rays by the seed coats. It is hence evident that the Einstein Photochemical equivalent law applies to the germination of light-sensitive seed; in photochemical processes the photochemical yield in equally absorbed rays is proportional to the wave length. It is assumed that all rays passing through the coats are absorbed by the seed contents. In the light-germination process the germination

yield.

yield is proportional to the number of quanta which act upon the seed contents, since in equal energy value the quanta are proportional to the wave lengths. Light-germination is believed to be a photochemical process occurring in the seed contents and not in the coats. The work was repeated upon the dark-germinating seed of Phacelia tanacetifolia without inhibiting germination, due, it is believed, to the light source being too weak.

317. Of 3 pairs of white rats kept in a photographic dark room, the 1st pair was exposed to radiation from a quartz mercury-vapour arc for 15 min. daily, at 40 cm; the 2nd pair was kept in the dark, but fed on a diet similarly radiated; and the 3rd pair received neither radiation nor radiated food. The 1st pair showed the most rapid growth; the 2nd, next; and the 3rd pair grew most slowly. Chickens (23) were radiated for 30 days following hatching for 15 min. daily at 40 cm., while a non-radiated control was fed on the same diet. The radiated animals grew more rapidly than the non-radiated, of which 1 died of malnutrition on the 6th day and another on the 10th day. Rabbits were radiated, beginning at 54 days after birth, for 39 days. Here also 1 in the non-radiated control group died of malnutrition.

318.* Investigations at the Station of Agricultural Physics and Climatology at Montpellier show that, although the growth of the grape depends on the amount of water supplied by the vine, a certain amount of water is obtained by the grape at favourable opportunities direct from the atmosphere by osmosis through the skin. The water vapour of the atmosphere can only penetrate into the grape when its pressure is sufficiently high and the speed of penetration depends on this pressure. The growth curve of the grape is related to a curve combining the duration of relative humidity above 70 per cent. and the rainfall. The observations show that in the central regions of France at any rate, rain is not the only source of water used by vegetation and they also confirm, what has been known to vinegrowers of the country for a long time, that the humidity of the mornings and evenings in August is particularly favourable to the swelling of grapes.

319. Studies of the rain and temperature charts in Connecticut during the last few years, considered with reference to the outbreak of Aphids in orchards in 1927, lead to the conclusions that the growth of the plant is the most important factor in outbreaks of the kind then experienced, and probably rainfall is indirectly influential, promoting a rich succulent growth that favours Aphid abundance. Sudden heavy rain doubtless destroys many Aphids, but this did not seem to have much effect in 1927. Probably continuous rainy periods when the ground is kept soaked are more effective in producing favourable conditions than infrequent downpours. In 1925 the high temperatures in early June probably promoted development of the parasites or increased the tendency to migration among the Aphids, which caused them to disappear from the trees.

320. Observations on the influence of varying climatic conditions on the more important insects and fungi infesting

crops

crops have been made at the Federal Viticultural Experiment Station, Lausanne, since its foundation in 1886. The author gives a summary of these observations on four important vine pests, which include Phylloxera vastatrix, Planch, and Clysia (Cochylis) ambiguella, Hb. Statistics indicate that the spread of P.Vastatrix is favoured by hot, dry summers that dry the upper layers of soil and induce extensive migrations of the young aphides. On the other hand C. ambiguella, which originated in temperate regions, cannot easily withstand great heat or dryness, the eggs and young larvae being particularly susceptible to desiccation. This moth, therefore, causes more damage when the spring is damp and cool, particularly when the flowering of the vines is poor and abnormally prolonged. In hot dry years little damage will be done, especially if the periods of heat and dryness coincide with oviposition and the hatching of the caterpillars, which take place from the end of May to the beginning of June and from the end of July to the beginning of August.

321. In this contribution from the School of Hygiene and Public Health at the Johns Hopkins University, Baltimore, the authors show that under the conditions of the experiment the susceptibility and resistance of guinea-pigs to infection with a virulent strain of tubercle bacillus was no different at a temperature of 80°F. with 79 per cent. relative humidity, and a temperature of 69°F. with 45 per cent, relative humidity. The authors rightly remark that what is true of the guinea-pig is not necessarily true for other animals and human beings, especially in this case as the guinea-pig is originally a tropical animal.

322. Shade trees near sod ground have been found to be a common habitat for adult Melanotus. Temperature experiments show that they cannot live long on the surface of sod ground on hot days. Their choice of temperature, determined in a gradient, is much below the usual maximum temperature in open fields during summer. Negative phototropism causes the beetles to seek dark hiding places during the day. The larvae of Melanotus are more resistant to heat than the adults but do not voluntarily seek higher temperatures. Seasonal movements of wireworms may be closely correlated with soil temperature changes.

323. The lysimeter experiments, which were fully described in the 1925-26 report were again continued on exactly the same lines this year; the only difference being that the whole installation was roofed in with glass. The provision of this complete protection against natural rainfall has made possible the complete control of the water factor. The glass roof was completed on the 26th April 1927, so that from that date the pots got no more rain. Watering was carried out according to the existing needs of the individual grasses that is to say, when percolation water no longer came through or came through in only very small quantity. An effort was also made by the adoption of this practice to keep as far as possible the same water level in the different pots, though this could not be completely achieved.

According to our observations the following grasses used the amounts stated of the available water:

Avena

Avena elatior	545.74 mm.	- 86.21	per	cent.
Pholaris arundinacea	509.24 "	- 83.11	"	"
Poa pratensis	480.19 "	- 82.26	"	"
Dactylis glomerata	476.99 "	- 83.58	"	"
Alopecurus pratensis	471.33 "	- 83.09	"	"
Phleum pratense	450.60 "	- 82.19	"	"
Lolium perenne	406.67 "	- 79.28	"	"
Festuca pratensis	348.64 "	- 71.38	"	"
Fallow	270.44 "	- 77.12	"	"

The grasses were in each case harvested when they began to flower - Timothy (Phleum pratense) and Seed Canary Grass (Pholaris arundinacea) on the 4th July, and the remaining grasses on the 10th June. The second cut was carried out at the same time for all the grasses - on the 4th August.

The reason that drainage was so high in April in comparison with the other months is that the lysimeter installation had not then been roofed over. More detailed information as to the water economy is given in the tables which accompany this article dealing with the period 1st April to 1st October.

324. The lay-out of the experiments has already been described in the report for the year 1926-27. The basic manures applied to the plots were 150 kg. potash and 100 kg. phosphoric acid per hectare. The nitrogen was given in the form of lime nitrogen, plot 1 receiving no nitrogen, while plot 2 and plot 3 received respectively 60 kg. and 120 kg. per hectare.

During the course of the investigations 507 mm. of natural rain fell. Apart from this, part of both the meadow and the pasture received 90 mm. of artificial rain and another part 370 mm. The daily average was thus 2.9 mm. on the unwatered plots, 3.4 mm. on the lightly watered plots, and 5.0 mm. on the heavily watered plots.

Three cuts were taken from the meadow, five from the heavily watered pasture plots and four from the other pasture plots.

The following weights of hay, calculated on a basis of 85 per cent. dry matter were harvested from the meadow:

	0 kg.N. dz.	60 kg.N. dz.	120 kg.N. dz.	Crude Protein 0 kg.N. dz.	60 kg.N. dz.	120 kg.N. dz.
Unwatered	90.99	125.85	127.30	12.74	17.24	17.42
Lightly watered.	118.74	137.83	149.49	19.47	19.71	23.02
Heavily watered.	137.72	168.77	189.03	21.35	23.46	30.45

The differences in the yields are very great and show that, even in such rainy years, considerable increases in yield can be obtained by means of artificial rain. We attach very particular importance to the observations made on the plant composition. The botanical analysis showed in the second year of the experiment a totally different state of affairs than existed before.

1st

1st Cut.

The perennial ryegrass (Lolium perenne) is fairly evenly represented on all the plots - nothing else was to be expected - but on the meadow plots it has fallen off considerably. With heavy nitrogen manuring and plentiful water it still makes its presence evident in the second year; with plentiful water but no nitrogen, on the other hand, it falls away rapidly. The position is reversed on the unwatered plots; here it holds out on the plots without nitrogen, whereas on the plots heavily manured with nitrogen its percentage representation is reduced. The variation in the quantity of cocksfoot (Dactylis glomerata) in the meadow quickly becomes evident. This grass, which was represented in the previous year to the extent of only 10 per cent. to 20 per cent., now already claims (in the second year of the experiment) surface area of 40 per cent. to 50 per cent. The behaviour of wood meadow grass (Poa compressa) is also typical, which grass has spread more particularly on the plots with heavy nitrogen applications. The meadow fescue (Festuca pratensis) has up to this point been able to hold its own only on the heavily watered plots - on the other plots a falling off is recorded. White clover has spread further on the heavily watered plots which received no nitrogen.

2nd Cut.

Perennial ryegrass has fallen back further as compared with the 1st cut. Of the grasses which have increased cocksfoot takes first place. Timothy (Phleum pratense) is hardly to be found at all. White clover occupies on the plots without nitrogen up to 46 per cent. of the surface, while on the plots which received 120 kg. nitrogen it has disappeared entirely.

3rd Cut.

At the 3rd cut the cocksfoot has gained the upper hand on all the plots. The plot which was heavily watered and which received 120 kg. nitrogen consists to the extent of 86.7 per cent. of this grass. No other grass has been able to make use of the available foodstuffs and of the situation to the same overwhelming extent, and to produce so heavy an aftergrowth.

The following yields were obtained from the pasture plots:-

	Hay yields.			Crude protein.		
	0 kg.N dz.	60 kg.N. dz.	120 kg.N. dz.	0 kg.N. dz.	60 kg.N. dz.	120 kg.N. dz.
Unwatered	71.44	62.86	65.61	12.72	11.82	12.33
Lightly Watered	95.72	81.62	82.04	16.85	13.62	14.69
Heavily Watered	137.16	92.33	124.34	27.98	19.02	25.49

Again here the alteration in the plant composition is worthy of particular attention. At the 1st cut it was unfortunately impossible to differentiate clearly between perennial ryegrass and meadow fescue since the former had a number of panicles curled round the stem and in certain cases rolled leaf buds. Consequently

the

the two species had to be combined in one group; one would not, however, be wrong in assuming that the greater proportion consisted of perennial ryegrass. The plant composition shows even by the 2nd year of the experiment a complete change; the effect of utilisation shows itself here definitely. At the 1st cut there are two grasses in particular which have extended their hold namely, perennial ryegrass and wood meadow grass. The remainder of the grasses and the clover too play a secondary role. At the 2nd cut we find almost the same state of things, except that the wood meadow grass, as a result of its slow development, has spread further. Cocksfoot and Timothy also show an increase but as compared with the previous year they have fallen off. White clover has too come more into prominence, more especially on the plots which have had no nitrogen, while on the nitrogen plots the percentage of white clover shows little change. At the 3rd cut, white clover takes first place on all the plots which have received no nitrogen, while on the plots which have received heavy dressings of nitrogen it has not advanced. On the unwatered plots the application of nitrogen has apparently had less effect on the white clover since on them it has maintained its position.

And now as to the economics of artificial rain! If we, as we have done hitherto, fix the cost at 7 Pfg. per cm. and take the price of hay as 6 M. per dz. we arrive at the following conclusions:

		pfg
Meadow. lightly watered		14.7
" heavily "		8.4
	Average	11.55
Pasture, lightly watered		13.2
" heavily "		8.3
	Average	10.75 pfg

As compared with previous years we thus find closer correspondence between the results on meadow and pasture of the use of artificial rain.

325. Experiments with copper and sulphur fungicides are said to have given satisfactory control of Cladosporium fulvum on tomatoes grown in greenhouses. Laboratory studies are reported, which show that at room temperatures a nearly saturated atmosphere is necessary for the germination of spores of the fungus. The best germination occurred at relative humidities of 98 per cent. and 99 per cent. and there was no germination at ordinary temperatures when the humidity fell to 96 per cent. or lower.

Following these studies an investigation was made of air circulation by forced ventilation on humidity and fungus activity, and ventilation systems were investigated in which the humidity was artificially lowered. In a greenhouse where the air was theoretically changed in from 22 min. to 32 min. there was no leaf mould except in one corner, and there it made no progress during a period of 4 months when the ventilation fan was in use.

326.* Using marigolds exposed continuously in pots to an air current of approximately 15 m.p.h. the author found that:

1. A portion of the tender foliage was actually destroyed by wind whipping.

2. Deformation of the main stem was marked in early growth stages.

3. Rate of growth as measured by height of plant was immediately reduced.

4. Time of maturity was increased by wind about 10 days in a 60-day growing period.

5. Yield of dry matter was reduced 48.8 per cent by wind.

6. Total water requirements per pot did not vary significantly.

7. Water requirements per unit of dry matter produced were approximately doubled by exposure of plant and pot to wind.

8. The number of secondary branches formed was apparently increased 42.8 per cent. by wind.

327. * The results of the experimental work reported in this paper support the following conclusions:-

In most summer crop plants constitutional disturbances having a serious influence on them are called into effect when the plants are subjected to chilling, even though the temperature does not go as low as 0°C.

The outstanding result of the investigation was the very evident effects of chilling on certain plants and the high degree of resistance in others. The duration and the intensity of the cold were important factors in determining the nature of the reactions.

Marked differences in relative hardiness between varieties was observed.

Cow peas, peanuts, maize, and velvet beans were far more severely injured in wet than in dry soil. Soy beans behaved in the contrary manner, although the injury in the latter case was slight and may possibly have been due to drought.

In experiments with cowpeas, cotton and velvet beans, young plants suffered materially more than old plants treated in a similar manner.

Tap water solutions of various salts were applied to the plants to ascertain whether any salts would act protectively against plant injury by chilling. Equal volumes of tap water were applied to control plants. Potassium nitrate was found to afford considerable protection,

with

with potassium chloride standing next in order. Then came the control lot, and then, in descending order of effectiveness the lots to which calcium chloride, calcium nitrate, sodium chloride, and sodium nitrate were applied. Sodium nitrate and sodium chloride were in some cases fatally injurious when chilling was continued for from 36 hr. to 60 hr., the former salt being the more injurious.

328. * A study has been made of the relation of temperature, spraying, and type of infection to the transportation rots of peaches, and an attempt is made to equate the different temperature and infection values.

On the basis of temperature values developed and with the temperature conditions known, it has been found possible to picture the approximate course of development of the rots.

Monilia and Rhizopus rots increased in diameter at an approximately uniform rate in the different stages of development, the diameter of the rots thus becoming a fairly accurate basis for temperature comparisons. For the purpose of the present studies neither the area, nor the volume of the rot, nor the weight of the rotten tissue could be used as a basis for temperature equivalents.

With both Monilia and Rhizopus, low temperatures had a relatively greater inhibiting action upon development during the incubation period than during the later growth. With both incubation and growth a 5°C. change in temperature had a greater effect at the lower temperatures than at the higher ones (experiments ranging from 0°C. to 30°C).

Apparently sound unsprayed peaches developed about four times as many rots in transit as similar sprayed peaches.

329. The larval life of Popillia japonica, Newm., consists of three instars, the 2nd and 3rd of which, in the neighbourhood of Philadelphia, are the normal hibernating stages, though occasionally a few larvae of the 1st instar are obtained during the winter and early spring. Laboratory observations were made on the quantity factor of cold hardiness in this insect. 1st instar larvae exposed to 10°C. on hatching survived for 14 days to 18.4 days, developing more resistance to cold as they became older. During the period of preparation for the 1st moult, they became more susceptible to cold, the resistance reaching a minimum again in larvae kept at 25°C. for 20 days, just after the 1st moult, and immediately beginning to increase with the growth of the 2nd instar the full-grown 2nd instar larva being very resistant, since it is able to pass the winter under field conditions.

Since all larvae found during the winter months in field surveys are in instars that are shown experimentally to be resistant, it is probable that any larvae present at the beginning of cold weather in the less resistant stages were

killed

killed. The quantitative differences in the time of survival of larvae in the field and under experimental conditions are probably influenced very largely by the difference in food.

330. * Cold hardiness, both to the intensity factor and to the quantity factor of low temperature, were studied in the 2nd and 3rd instars of Popillia japonica, Newm. (Japanese beetle). Brief observations were made on pupae and adults with regard to cold hardiness. Japanese beetle larvae are somewhat periodic in their cold hardiness to the intensity factor of low temperature, less so than the oak borers previously studied, and more so than the aquatic insects. Disease incidence, nutritional state, and degree of dehydration are associated with cold hardiness to the intensity factor of low temperature. Development of cold hardiness to the quantity factor of low temperature is associated with loss of cold hardiness to the intensity factor except in extremely dehydrated individuals. Marked permeability changes associated with enzyme action occur at the vital temperature minimum.

331. The author calls attention to the importance on plant growth of the water factor, and divides the investigations which have been carried out on the subject into three categories:-

1. Those which are designed to show the influence of different quantities of water on the growth of cultivated plants and to discover the optimum quantity necessary to produce the highest yield.

2. Those which aim at the determination of the specific water i.e. the quantity of water required to produce 1 kg. dry matter.

3. Those of which the object is to discover the influence which the vegetation factor water exerts on the development of cultivated plants, when varying quantities are supplied at different stages of growth.

Some references are made to the investigations which have been carried out in categories 1 and 2, but the author points out that the conditions under which investigations in category 3 are made are nearer actual conditions in the field where rainfall varies throughout the period of the life of the plant.

References are made to the work of Hellriegel, Wollny, Pfeiffer, Rippel and Pfotenhauer, Gain, Rivier, Zelensky, Moliboga, Wilfährt, Römer and Wimmer, Robertson and Kezer, Harris and Welch. The investigations mentioned extended in certain cases not only to the comparison of yields when varying quantities of water are given, but to the examination of the effects on the development of the different parts of the plant.

The greater part of the article is taken up with an account of the author's own investigations on the influence of

drought

drought periods on the spring wheat variety Ulca at different stages of growth. The experiments were carried out in pots having a capacity of 12 kg. of soil. All the pots were supplied with the same plant foods in optimum amount, and 12 plants were allowed to grow in each pot. There were in all 13 groups of pots, in which the quantity of water given varied in different ways at the most important periods of growth. Each group consisted of 4 pots all treated alike. The whole growth period was divided into the following four more or less equal periods. 1. Sowing to end of tillering. 2. End of tillering to end of shooting. 3. End of shooting to end of flowering, and 4. End of flowering to ripeness. Since the soil used had a high water capacity, the quantity of water supplied amounted to 20 per cent. and 45 per cent. of its water-retaining capacity.

The article concludes thus:-

"Summing up our experiments which we have now discussed and compared with similar work of other investigators we arrive at the following conclusions, which are in contradiction to the conclusions which have been drawn by Zelensky and Moliboga.

1. Drought periods occurring at any time in the vegetation period have a harmful effect on the development and the power of production of the wheat plant.

2. The injurious effect of drought periods is all the greater the longer they last and the earlier they occur before the appearance of the ears.

3. The critical period of the summer wheat variety Ulca in the matter of water shortage occurs in the first stage of development between sowing and shooting, and is even more marked between sowing and the end of tillering. Our earlier experiments have shown the same thing to apply in the case of the summer wheat variety Beloturka and we are of the opinion that with all varieties of summer wheat which are indigenous to regions having a continental climate, the critical period as regards water shortage is to be found in the development stages preceding the appearance of the ears."

A bibliography of the experiments discussed is given at the end of the article.

332. Water being an essential constituent of germ cells, it seemed possible that seeds might respond to variations of moisture content especially if they are stored at a particular humidity for a long time.

Accordingly, 2 varieties of wheat - Pusa 4 and Pusa 12 - were stored for 6 months at different humidities ranging from 10 per cent. to 85 per cent. controlled by mixtures of sulphuric acid and water of appropriate concentrations At the end of 6 months they were taken out and their germination capacity determined. Those at 85 per cent. humidity were all infested with fungus and were discarded.

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The germination was visible on the 3rd day when the counts were started. The results bring out some interesting points.

The optimum of germination occurred when the seeds were stored at 50 per cent. humidity, but the two varieties showed a marked difference. Pusa 4 is not so sensitive to the value of humidity at which it is stored and can stand a higher humidity much better than Pusa 12 which is very sensitive to variations of humidity at which it is stored.

It is well known that Pusa 4 does well at places where the humidity is high in the storing season; while Pusa 12 is more suitable for drier regions like the North of India. Further it is known that Pusa 12 is softer than Pusa 4 and is likely to be affected by changes of moisture; and in fact, at all humidities the moisture content of Pusa 12 is always higher than that of Pusa 4. It is possible that the moisture content at 50 per cent. humidity might afford a method of defining the degree of hardness or softness of a particular variety not only in the mechanical sense but as regards its general behaviour towards water intake at the time of germination. The work is being continued with other varieties.

333. *Economic plants of different varieties were grown under daily light exposures of 10 hr., 11 hr., 13½ hr. and 15 hr., and under the normal light exposure, 11 hr. to 13.2 hr. (sunrise to sunset).

An 11-hour daily light exposure proved to be more favourable to the blossoming of both Porto Rico and Key West sweet potatoes than a 13½-hour exposure. The evidence as to the effect of these light exposures on vine growth and tuber formation was inconclusive.

The growth of the different onion varieties under the varied light exposures showed onions to be very sensitive to the duration of the daily light period. Different varieties varied in their responses to different day lengths. An exposure sufficient in length to cause bulb formation in one variety may be wholly inadequate in the case of another. For this reason, certain varieties which form large bulbs in temperate latitudes may fail wholly to form bulbs when grown in the Tropics. In the lower latitudes where the temperature permits planting throughout the year, not only is it essential to select such varieties as will form bulbs under the day lengths which prevail in these latitudes, but the favourable planting time as well must be determined with regard to the seasonal day length. While the shorter days favour leaf growth, they inhibit bulb formation, for which the longer days are necessary. Of the four varieties included in these tests, one only, Bermuda White, showed itself to be well adapted for growing in such latitudes as have a maximum day-length only shortly in excess of 13 hr. Though some individuals of the Silver King (Giant White Tripoli) variety formed bulbs, the varietal adaptability to such day-lengths could be considered as only partial. The Prize-taker and Yellow Globe Danvers varieties are wholly unsuited for growing under such day-lengths, plants in the main remaining in the spring-onion stage rather than forming bulbs. Under daily light exposures of a little

more

more than 15 hr., normal bulb formation was rapid in all four varieties.

The tendency of the onion to form more than one core, or to split into two or more individuals was not shown to be correlated with the length of daily light exposure, but rather to be a varietal characteristic.

The Irish Cobbler, Red Bliss, and Lookout Mountain varieties of potato differed considerably in sensitiveness to differences in length of daily light exposure. Of the three the Lookout Mountain variety proved to be the most sensitive, and the Red Bliss the least so. Whereas the longer exposure favoured growth of tops, the shorter exposure favoured tuberization.

Porto Rican corn showed pronounced differences in growth and production under normal and 15-hour daily light exposures. Under the lengthened exposure blossoming was delayed, a much greater height was attained, and the production was inferior in number and size of ears to that under the normal light exposure.

Red Spanish pineapples were grown under daily light exposures of 10 hr., 11 hr., 13½ hr., 15 hr. and under normal light exposure. Under the longer exposures blossoming was delayed, the size of the fruit was considerably larger, the production of slips was notably greater, and the total growth was increased.

The most clearly evident and consistent effect of the longer daily light exposure under which the beans were grown, 13½ hr., was the increased vegetative activity as shown by the greater height and greater length of life under the longer daily illumination.

334. This paper is concerned with experimental studies on the phototropism of Cydia (Laspeyresia) molesta, Busck (Oriental peach moth) and C. (L) pomonella, L. (codling moth). An apparatus containing 4 compartments which may be separately illuminated is described.

The following is taken from the author's summary. "There is an approximately equal distribution of the adults of both species in the compartments when these are uniformly illuminated with white lights; with bulbs varying in strength between 10 watts and 100 watts, the strongest light attracts the most moths. When these insects are given the choice of coloured lights of approximately equal ratios of intensities, they are nearly all attracted to blue and violet, the latter being preferred. Purple ultra lights, however, are the most attractive. Few or no adults go to red light. Orange, yellow, and green that is devoid of blue rays, are also unattractive when tested with bluish lights. C. pomonella appears to be somewhat more positively phototropic to blue and violet lights than C. molesta. The latter, however, is probably able to see ultra-violet light. The response of males and females of both species to coloured lights seems to be similar.

When

When a weaker or less attractive coloured light is placed at a right angle to a stronger or more attractive one, more moths go to the weaker light than when such light is situated opposite the stronger.

Very few Oriental peach moths come to ordinary white or artificial daylight electric lights in the orchard, and traps with these have for a few seasons proved of no value in controlling this insect.

335. Winter wheats over the whole of the Ukraine are stated to have suffered severely in 1927 from an epidemic of bunt (Tilletia levis and T. tritici), the incidence of which attained 70 per cent. in some localities and averaged 55 per cent. in the whole territory of the Republic. A similar epidemic was also observed in 1923, while in the intervening years the attacks were much lighter. The scope of the investigation described in this paper was, therefore, an attempt to elucidate the causes that determine these epidemic outbreaks in certain years. Field observations and laboratory experiments, coupled with a detailed study of the meteorological factors which prevailed during the period from 1922 to 1927, indicate that there exists a close relationship between the temperature at the time of sowing the winter wheat and the degree of bunt in the ensuing crop. In the author's experiments (admittedly somewhat rough) it was found that the optimum temperature for the germination of wheat lies between 20°C. and 25°C., for the germination of the spores of both species of Tilletia between 10°C. and 15°C. and for the infection of the wheat seedlings between 5°C. and 10°C. In both epidemic years the general trend of the temperature curve during the sowing period in autumn was identical, both being lower than the mean temperature curve for the same period in the whole 6 yr. The temperatures during the subsequent periods of growth of the wheat play no part in determining the incidence of infection, but in the early stages of growth may help the plants to outgrow the parasite and thus to mask the effects of the infection. An indirect proof of the depressing effect of the fungi on the hosts was the observation that the apparently healthy ears in plants raised from contaminated seed were shorter than in the controls, and contained fewer fertile spikelets. Both species of Tilletia behaved in the same way under the various temperatures tested. Moisture relations appeared to have no effect on the incidence or further development of the disease.

336. *1. In artificially induced smut epidemics, the effect of environmental factors on the prevalence of infection in selfed lines and crosses of corn was studied. A comparison was also made of the reactions of lines of corn to normal field infection as well as to hypodermic inoculation with the smut-producing organism in the field and in the greenhouse.

2. Dry weather conditions, as expressed by a low

number

number of days of precipitation and a high percentage of sunshine, were found to be conducive to the prevalence of smut. Temperature was not so important a factor as either number of days of precipitation or percentage of sunshine.

3. Corn seedlings proved to be very susceptible when hypodermically inoculated. Infected seedlings are frequently killed by the smut pathogene. Yet observations and experiments over a period of years indicate that seedling infections with gall formation in the field are of comparatively rare occurrence. The specific reason for this is not known. Environmental factors do not satisfactorily explain this lack of infection. It seems possible that corn seedlings are morphologically or functionally resistant to natural field infection.

4. A correlation of $+0.40 \pm 0.10$ was found between natural infection in a smut epidemic and artificial infection of the same strains of corn by hypodermic inoculation with a mixture of 8 physiological forms of smut.

5. Some lines of corn were resistant to smut infection under natural conditions as well as when hypodermically inoculated with a mixture of sporidia of 8 forms of smut, when the plants were 3 ft. high. Other lines were resistant to natural infection but susceptible when hypodermically inoculated.

337. This paper discusses the factors to be considered in attempting to forecast insect outbreaks. Where extended life-history studies have been made of a particular species, it is possible to anticipate to some degree its prospective abundance at the beginning of the following season, but the influence of climatic conditions, parasites, etc., render it impossible to make an accurate forecast at the beginning of the growing season of its final abundance and the extent of damage to any particular crop. The relative size of the autumn population, conditions affecting hibernation, abundance of food plants, earliness of spring activity, summer temperature and extent and types of rainfall, and the rate of multiplication and number of generations, must all be taken into account in respect of each species, some of which may be susceptible to fairly accurate forecasts, while others present difficulties that cannot be overcome.

338. Anuraphis helichrysi, Kalt., is normally very abundant in North Wales, but sometimes its numbers are greatly reduced by frosts. The eggs are laid round the base of the buds of plum trees, and may hatch before the buds are developed. In such a case, if snow or sleet occurs and freezes upon the trees, great mortality of the Aphids results. Observations on the potato Aphid (Macrosiphum gei, Koch) in the Bangor district during 1921-27, showed that the worst outbreaks occurred during cool weather in early summer, the insects being checked by fungi during warm, damp weather, and by parasites and predators during hot, dry periods. In North Wales in 1921, numerous young colonies of Brevicoryne brassicae, L., on cabbage died out owing to hot, dry days.

Plutella

Plutella maculipennis, Curt. (cruciferarum, Zell.) has been controlled on several occasions, when seriously threatening swede crops, by sudden and violent rain storms. The lower surface of the leaves, where the larvae feed, become covered with mud, and this kills the larvae. Severe attacks of Pegomyia hyoscyami var. betae, Curt., in North Wales during June 1926 and 1927, were controlled by cold, wet weather when the larvae of the first brood were about to pupate.

399. Wide variations in resistance to injury from cold in the autumn have been found to exist in inbred strains of corn, in recombinations of inbreds, and in commercial open-pollinated strains, as they approach maturity. Some inbreds were killed by a few hours exposure to temperatures ranging from 45°F. to 50°F. Many inbreds, recombinations, and commercial strains were injured or killed by a succession of cold nights during which temperatures ranged from 45°F. to 33°F. Other inbreds and recombinations withstood 6 hr. of 32°F. to 30°F. and a few others withstood 28°F. for hours. These differences have been observed under natural conditions for the past 5 yr. and some of them were found under accurately controlled artificial conditions in the field in 1928.

In the spring of 1925, when field temperatures dropped below 32°F. for several hours, reaching as low as 25°F. a few inbreds and recombinations, 4 in. to 6 in. high, escaped without apparent injury. Under the same conditions many other strains were severely injured and some never recovered from the injury.

Seed matured on plants high in cold resistance, produced plants more resistant to seedling blights, lodging and stalk breaking than did seed gathered at the same time from corresponding plants previously injured by cold.

400. Experiments with electrically heated hot frames were designed to give information on the following points:-

1. The time required for growth of lettuce in cold and heated open ground, in cold frames and in hot frames where both earth and air could be heated to various temperatures.

2. The use of cold frames and hot frames compared with open ground for lettuce.

3. The conditions of growth necessary for lettuce in frames and in open ground in different seasons so as to ascertain as precisely as possible the extremes of the season for growing lettuce.

4. The rate of growth and the yield of lettuce at different temperatures showing the time required to reach a given stage of development and also the yield obtained after a given time.

5. The relative rate of growth or the increase of weight for every 1°C. rise in temperature during certain limited periods of growth.

6. The critical temperatures for the formation of heads.

7. Rules for regulating the heating of the frames.

401. *Three climatic factors, rainfall, air humidity and temperature, have been studied to determine the influence of each on the root rot disease. Of the three factors, rainfall is outstanding in its importance. Humidity is seen to have no direct influence. Temperature for the crop-producing portion of the season is seen to be favourable to the development of the disease. Toward the end of the growing season, lowered temperatures reduce root rot severity in spite of favourable moisture.

A further analysis of the data reveals that an adequate supply of moisture at the early part of the season favours development of the disease regardless of the rainfall additions. In mid-season, however, there usually occurs a drought period which checks root rot, and in 3 out of the 5 years under study, spread of the disease was completely stopped for a considerable period.

In 1926, no mid-season drought occurred, and root rot continued to develop throughout the season with the result that more than 50 per cent. of the plant population died. The suppression of root rot in those years when the soil moisture was limited and its continued development in a year of abundant moisture show that rainfall is a very critical factor and actually controls mid-season and late-season development of the disease. The importance of the moisture factor is further shown by the increase of root rot following the advent of September rains.

Favourable temperature for root rot is seen to occur during the crop-producing portion of the season. That is, the temperature is favourable for development of the disease to a high degree of severity. In September and October, however, lowered temperatures become the limiting factor and cause a sharp reduction. This check in the disease occurs too late in the season to lessen its destructiveness, because plants dying at this time have already produced a crop which is not greatly injured by such delayed death of the plant.

402. The subject is dealt with under the headings of material and methods and results, followed by a discussion. A list of 33 references to the literature is included.

403. A detailed account is given of a study of the relation of soil temperatures to the development of cotton wilt (Fusarium vasinfectum) under controlled conditions in the greenhouse. The results are also given of observations on the effect of the same factor under field conditions.

According to the author, little or no wilt commonly appears in Arkansas before early in June. The disease develops slowly during June and reaches its maximum in July and early August. Some of the more resistant varieties are said to have a longer period of incubation, and the greatest amount of wilt appears in them later in the season.

Under controlled soil conditions, Trice cotton is said to be affected with wilt more severely when soil temperatures are near 30.5°C. but temperatures from 28°C. to 32°C. are favourable to wilt development. The disease is said to fall off rapidly above 33°C. and little wilt was observed

above

above 35.5°C. The amount of wilt is said to decrease gradually below 28°C., and only small amounts were observed to occur at 18°C. The author believes that serious cotton wilt infections probably will not occur in the field at soil temperatures below 23°C., except in especially susceptible varieties.

The effect of soil temperature upon the development of cotton wilt is said to be closely correlated with the effect of temperature upon the growth of the cotton wilt fungus in the laboratory. The optimum temperature for the development of cotton wilt is believed to be slightly higher than the optimum temperature for the development of the fungus.

Air temperatures as low as 24°C. are said to check considerably the rate of development of F. vasinfectum in the stems of the cotton plant, even though soil temperatures are favourable for its development in the roots. While the most favourable soil temperatures for the development of wilt were slightly below those determined by others, it is believed that they fall within the range which is not at all unfavourable to the development of the cotton plant.

Under field conditions, air temperature records are said to suggest very strongly that the failure of appreciable amounts of wilt to appear even in extremely susceptible varieties for more than one month after planting is due to the inhibiting effects of low soil and air temperatures rather than to any lack of susceptibility in cotton seedlings. It is considered that in all probability soil temperatures are most favourable to the development of wilt during July and August.

A close relationship was found to exist between the conditions which bring about rapid saprophytic development of the pathogene in the soil and the development of cotton wilt, and it is suggested that under natural conditions warm, well aerated sandy soils with sufficient amounts of organic matter for the development of the pathogene may allow a rapid spread of the fungus through the soil and thus favour the attack on cotton roots.

404. The author defines effective rainfall as "a daily measure of the soil moisture which originates in rain and is available for plant growth. It is derived from the rainfall data in the following manner.

$$E_n = r_n + kr_{n-1} + k^2 r_{n-2} \ldots + k^{n-1} r_1$$

where r_n is the rainfall of the 24 hr. ending 8 a.m. on day n.

"The amount of rain written off between successive days is

$$(1-k)r_{n-1} + (L-k^2)\ r_{n-2} \ldots + (1-k^{n-1})r_1, \text{or } (1-k)E_{n-1}.$$

It includes the loss from run-off, percolation, evaporation, and transpiration as well as the moisture held in the soil in the "un-free" condition.k, therefore, is a function of temperature, air humidity, and soil conditions.

"In part, these sources of loss counterbalance each other, and, for a large range of soils in the Tropics, k has a value approximating to 19/20.

"Under tropical conditions, k becomes a measure of the "free" or physiological, water remaining in the soil.

"For

"For agricultural plants it is possible to draw two curves giving the upper and lower limits of their water requirements at each stage of their growth, and the dual curve so obtained has a varietal significance.

"As a consequence of that variability of k which arises from soil conditions, it becomes possible to employ the effective rainfall for the estimation of crop areas in a given tract, and an analysis has been made in the case of the wheat and cotton areas of the Cawnpore District, India", which showed that the use of the regression equation would result in forecasts of the wheat area and of the unirrigated cotton area which would be more accurate than the present estimates. The two analyses "indicate that the effective rainfall constitutes a significant measure of the agricultural value of rain, and is a measure which possesses distinct advantages".

"Under conditions which permit the adoption of a constant value for k, the effective rainfall becomes a means of estimating crop yields, and an analysis has been made, in the case of the cane crop, of an estate in Barbados and, in the case of the cotton crop, of the Dhulia Farm, Bombay Presidency". The correlation between the aggregate effective rainfall of June and December and the yield of sugar cane was found to be

$$r = + 0.67 + 0.09.$$

"All attempts to trace an effect injurious to yield of excessive moisture have led to negative results, and it is only in the lower limits that moisture exercises a controlling influence". Because of the more complex nature of the problem the estimates of cotton yields were subject to greater qualification and are less convincing than those of crop areas.

405. The wheat varieties, Little Club, Jenkin and Washington Hybrid, 128, when continuously grown in the Pacific Coast States, rarely contain loose smut, but these wheats proved extremely susceptible when the flowers were artificially inoculated in a humid greenhouse at Arlington Experiment Farm, Rosslyn, Va. The loose-smut fungus of wheat infects only through the flowers of its host. At infection time the relative humidity of the atmosphere in the Pacific Coast States usually is very low. Through the use of chambers with definite relative humidities it has been found that the spores do not germinate within the flowers at the low humidities which normally prevail on the Pacific Coast when the wheats are in bloom, thus preventing infection. The flower-infecting loose smuts of oats and barley as well as the loose smut of wheat are rarely found in those sections of the country where the atmosphere at flowering time is very dry, although the host is widely grown. Loose smut in wheat grown on irrigated land was reduced but not controlled by withholding water at flowering time.

406. By subjecting several varieties of cabbage lettuce to varying lengths of day (natural day - 12 hr. - 9 hr. - 6 hr.) it has been found possible to give a clearer and sharper practical classification of the lettuces into winter, spring and summer groups according to the length of day best suited in each case to the formation of firm heads.

407. Experiments were conducted at the University of the Philippines to determine the effect of exposure to the sun on hatchability of eggs and how much exposure would produce the best results. Duck eggs were divided into 2 lots of 57 eggs each, 1 a check lot and the other exposed to the sunlight for 15 min. to 30 min. daily during the first 14 days of incubation. Also, a total of 1,267 chicken eggs was divided into 6 settings of 5 lots each. The 1st lot of each setting was used as the check or unsunned group, and the other lots in the settings were treated as follows: Lot 2 sunned 30 min. before placing in the incubator trays, lot 3 sunned as in lot 2 and 30 min. every 6 days thereafter to the 18th day, lot 4 sunned as in lot 2 and 30 min. every 3 days thereafter until the 18th day, and lot 5 sunned as in lot 2 and 30 min. every day until the 18th day of incubation.

The percentage of fertile duck eggs hatched in the unsunned group was 39.28 and in the sunned group 50.91. The average hatchability of all hens' eggs set was 56.78 per cent., 64.41 per cent., 62.86 per cent., 74.11 per cent., and 73.1 per cent. in the respective lots. The differences between the check lots and lots 4 and 5 were significant and in the other lots insignificant. The beneficial effect derived from sunning eggs was especially marked during the first 2 weeks of embryonic development. Sunning eggs every three days was considered to be more practical than sunning every day, due to the saving in labour.

408. The results of a 2-year study to determine the returns from lighted and unlighted pens of pullets and hens are reported. March-hatched White Leghorns were used in the trials. The 400 yearling hens used had trap nest records of 150 or more eggs in 11 months and were divided into 2 uniform lots, 1 of which was lighted and the other not lighted. 230 early maturing pullets and 230 slow maturing pullets were divided into 2 uniform pens each, 1 being lighted and the other unlighted. The lights were used from 1st October to 31st March. A uniform light-day of about 13 hr. was maintained throughout the experiment.

The response to lighting was almost immediate, and the lighted lots produced at a higher level from October to February than the unlighted lots. The unlighted lots, however, passed the lighted lots in production in February and March. Lighting levelled off annual production by increasing autumn and winter and decreasing spring and summer production. Pullets in the lighted lots showed an increase in production from 0.6 per cent. to 6.6 per cent, but yearling hens that had been lighted the previous year produced fewer eggs under lights than yearling hens without lights. The increase in feeding time from the use of lights was apparently not the entire cause of increased production.

It was found that the number of hours of light per day did not govern the amount of feed consumed. Birds producing the most eggs consumed the most feed. The total mortality in the lighted pens ranged from 6.9 per cent. to 15.6 per cent. and in the unlighted pens from 3.4 per cent. to 15.5 per cent. per year. Lighting materially increased the returns from lighted pens during the period when lights were used. In this test less than 2/5 egg per hen per month paid for the electricity used. The results indicate that a flock of 400 average pullets would yield an excess profit of ₱ 81.07 in 11 months over the cost of lighting.

Pertinent suggestions on lighting and wiring for poultry houses are also given.

409. The relation of weather conditions to crop yields during the 40-year period, 1882-1921, particularly in the north-western corner of the Great Plains region in Montana, is reviewed.

The normal precipitation at four places in this area is as follows: For the crop year, 1st September to 31st August inclusive, 13.51 in. at Havre, 13.9 in. at Miles City and 14.08 in. at Williston, N. Dak.; for the growing season, 1st April to 31st August, inclusive, 8.51 in. at Havre, 8.43 in. at Miles City, and 9.65 in. at Williston. It appears that "the normal crop-year and the growing season precipitations are close to the limit of successful farming by the continuous-cropping system..... When a growing season's rainfall is 2.3 in. below normal, the crop yield will be small. Under such conditions it is obvious that attention must be given to cultural practices that store and conserve moisture in the soil. In this region it has been shown that summer fallowing part of the land each year is a necessary adjunct to successful farming when wheat is the major or sole crop". The early and seasonal rainfall is erratic. "A year of abundant rainfall may be followed by one of great deficiency, or the reverse, and with no apparent order".

As regards temperature, it is stated that "in general, extremely hot spells of long duration are the exception rather than the rule. It is not the duration of the hot spell so much as it is the combination of other weather elements occurring simultaneously that has a damaging influence on crops. As a rule, high temperatures in this area are accompanied by very low humidity, no rainfall, clear sky, and fair wind movement".

Taking "the average per cent. of the 6 p.m. relative humidity during June and July ..... as the best-fitting single figure to represent the combination of all the weather elements during the critical part of the major growing season," it was found that "89 per cent. of the variation in crop yields may be said to be affected by the variations in the combination of the weather elements as expressed by (this) weather crop index."

Estimates of the probable yields of spring wheat on continuously cropped and summer fallowed land indicate much more favourable returns in the latter case. The fallowing of part of the land each year appears to be an insurance against drought. Corn raised for grain has not been a very certain crop during the period covered by this study. Rye has been a more certain grain crop than corn. Comparing rye, hay and corn fodder, it is shown that in only 1 year of the 40 did both crops fail at the same time. Livestock raising has been favoured by a fairly dependable grass supply over a long series of years. The system of carrying feed reserves from year to year has been found capable of tiding livestock over years of feed shortage in all but an exceptional year, like 1919. Good results have generally been obtained with the family garden. In many years it has produced a marketable surplus, and in all but a very few it has furnished the family with an ample supply of vegetables.

410 * 1. The weather affects the development of all phases in the life cycle of the stem rust organism.

2. Teliospores apparently lose their viability if kept for several months at high temperatures. It is suggested that this may explain the absence of rust on barberries in the Southern States.

3. Such factors as alternate freezing and thawing, alternate wetting and drying, light, and chemical stimuli did not have a measurable effect on the rest period of teliospores. Time seems to be the most important factor.

4. For the past five years at St.Paul, Minnesota, teliospores were shown to be viable several weeks before barberry leaves appeared in the spring.

5. After teliospores are matured, different lots of spore material, and even spores from different sori on the same straw, may require different lengths of time for germination. This probably facilitates barberry infection by insuring the germination of teliospores in several rainy periods.

6. Teliospores germinate in a wide range of H-ion concentrations, and apparently are not affected by light.

7. In nature teliospores usually lose their viability a few months after they mature but, if kept in cold storage, they may be preserved for nearly a year.

8. Field observations indicate that almost invariably teliospores can be found within a few rods of heavily rusted barberries.

9. The optimum temperature for the infection of Berberis vulgaris by Puccinia graminis secalis is 17°C. to 18°C. Infection was sparing at 22°C. to 23°C., and practically absent at 26°C.

10. Penetration of barberry leaves seems to be favoured by low light intensity, while the development of aecial infection, after penetration, appeared to be favoured by intense light.

11. There is some indication of a correlation between the mean temperature and rainfall in April and the earliness and severity of barberry infection in Minnesota.

12. Overwintering of urediniospores seems to be limited to seasons and regions in which temperature and rainfall favour the development of the uredinial stage at frequent intervals throughout the winter. Periods of alternate freezing and thawing are apparently a limiting factor.

13. In southern Texas weather conditions in summer seem to be more important as a limiting factor to the persistence of the uredinial stage than winter weather conditions.

14. In 1926 the predominance of stem rust on oats in northern Texas over that on wheat appeared to be associated with weather conditions during the previous year which were favourable for the development and persistence of volunteer oats.

15. The extent of the observable dissemination of urediniospores depends upon the amount of inoculum present. The rust from a single pustule usually develops through several generations before sufficient inoculum has accumulated to cause a noticeable infection at a distance of several rods.

16. When rust becomes plentiful throughout 1 or more fields of grain, it may spread, in observable amounts, for several miles to surrounding fields. There is circumstantial evidence that rust may be blown several hundred miles from a severely infected area.

17. Southerly winds have been shown to sweep up the Mississippi Valley, at the time stem rust is most plentiful in the south, with sufficient velocity to carry spores from Texas to the spring wheat area in less than 3 days. There is circumstantial evidence that conditions of this kind occurred from one to several times during the last 10 days in May and the 1st 10 days in June in every year for the past 25 yr. But there is no apparent correlation between the prevalence of these winds and the occurrence of epidemics in the spring wheat area.

18. A comparison of the mean temperature in May, June, and July in epidemic years with that in non-epidemic years indicates that there is a correlation between warm growing seasons and destructive epidemics in the spring wheat area.

19. Differences in the total precipitation or the number of rainy days during May, June, and July do not seem to be associated with the development of epidemics. Field observations indicate that severe epidemics sometimes develop in parts of the Red River Valley in which rainfall is totally absent. It is suggested that heavy dew may account for this condition.

20. No evidence was obtained of any specific meteorological condition or set of conditions that always accompanies epidemics.

411. In certain diseases where the pathogene penetrates the host through natural openings, the moisture condition of the plant previous to inoculation has been found to be very important in relation to the amount of infection secured. Experiments have been conducted upon the various host plants of the following pathogenes: Bact. lachrymans Smith and Bryan, Bact.pisi (Sack.) E.F.S., and B.tabacum Wolf and Foster. In each case it was found that plants placed during 1 day in a moist chamber previous to inoculation and then placed again in a moist chamber developed a great many more lesions than plants which were given the moisture treatment only after inoculation.

Temperature was also found to be important in the development of infection. The optimum, as measured by the size of lesions on the respective host plants, was found to be approximately 24°C. for Bact. lachrymans, 28°C. for B.tabacum, 12°C. for Bact. Holci Ken., 28°C. for Bact.coronafaciens Elliott, and 28°C. for Apl. michiganense, E.F.S.

The maturity of inoculated leaves appears to influence both the number of infections and the size of the subsequent lesions. It has been observed in certain cases that the newly expanded leaves commonly developed more lesions than older leaves.

412. Heterodera (Caconema) radicicola lives for months under favourable conditions. Egg masses may hatch 100 per cent. under best conditions. Larvae are killed at 43°C. in 10 min. and at 53°C. instantly. Egg masses are killed at 48°C. in 10 min. and at 58°C. instantly. Complete dryness kills larvae in 3 minutes and egg masses in 2 hr. Drying

at

at 70 per cent. relative humidity kills larvae in 10 min. and egg masses in 4 hr. Free eggs are killed more quickly than those in egg masses. Egg masses buried within roots survive for 48 hr. in complete dryness, for 5 days at 60 per cent. for 7 days at 70 per cent. and indefinitely at 90 per cent. to 99 per cent. Tests with sunlight and with ultra-violet rays (moisture and temperature favourable) show that ultra-violet rays kill nematodes. Sunlight killed larvae in 25 min., egg masses in 8 hr. free eggs in 1½ hr. Combined sunlight and drying killed larvae in 2 min. egg masses in 30 min. and eggs within roots in 8 hr. X-rays did not kill larvae or eggs in 35 min. In greenhouse tests with soils 10 in. deep, the organism was completely killed by 4 months' drying with stirring; when the soil was not stirred, so that the bottom was still moist and the humidity high in interspaces, there was only partial killing. Field results indicate practical application of this definite information.

413. This is a general discussion of the subject, which includes a table showing monthly reports of the occurrence of some insects of economic importance based on records obtained between 1920 and 1926 inclusive.

414. 1. *For lettuce the minimum temperature for growth lies between 7°C. and 8°C. in April, while it is supposed to be higher earlier in the spring, when the intensity of light is less and the day shorter. This does not mean that the limit for production of substance is to be found at this temperature, but that there is equivalence between the upbuilding operation of the roots and leaves of the plants, and the destruction caused by transpiration.

2. At a low temperature (8°C.) the plant grows exceedingly slowly. It needs then, even when the conditions of light are good, about 120 days to 130 days to give a yield of 5000 g. per 100 plants. When the temperature is raised 2°C. the time of growth is reduced to 60 days to 70 days, that is, about half. If the temperature is raised another 2°C. to 12°C. the time of growth will be reduced a further quarter. Further raising of the temperature will influence the time of growth at a diminishing rate. At a temperature of 23°C. to 24°C. the shortening of time is almost imperceptible.

3. If the growth of lettuce at different temperatures between the minimum and optimum for growth is plotted during a certain limited period an s-formed or sigmoid curve is produced. It shows the increasing rate of growth when the temperature is raised from the minimum to 15°C. to 20°C. and then the diminishing rate of growth till the optimum is reached at 26°C. to 27°C.

4. If the growth at different temperatures is plotted in a certain period, taken from the time when the rate of growth of the plant is uniform (the middle part of the curve) a curve is produced which shows a continuously decreasing rate of augmentation. If the time needed at different temperatures to obtain a certain crop, e.g., 50 g. of substance per plant, is known, it is possible to calculate the average growth per day at the different temperatures. The curve of this average growth is similar.

In other words, the initial application of artificial heat gives the best profit because it has the greatest effect on the growth, the later additions having gradually smaller effects.

5. The optimum for economical profit will therefore seldom be coincident with the optimum for the growth of the plant, but somewhere below it, dependent on the price of the artificial heat, the value of the produce of the plant at the end of the time of growth and the expense caused by other factors of production.

6. At a low temperature (12°C. to 14°C.) the lettuce produces exceedingly firm heads. When the temperature rises to more than 14°C. to 15°C. the head grows looser, and between 18°C. to 19°C. is the upper limit above which the variety Wheeler's Tom Thumb is unable to form a head.

7. Whether the temperature be kept constant day and night or allowed to change rhythmically with high temperature by day and low by night, the upper limit of temperature for forming head lies, with Wheeler's Tom Thumb, between 18°C. and 19°C. (within the limits of amplitude investigated).

8. A low night temperature reduces the transpiration and lessens the destruction of organic substance and will therefore contribute to increase the production of substance. In the experiments with lettuce this increase in the production of substance has been found to be very insignificant within a certain limited period. The greatest advantage of the low night temperature has been that with unchanged day temperature the average temperature has been lower. This has delayed the shooting of the flower stem, and even under hard forcing with high day temperature the plants then get the necessary time to form heads before the flower stem shoots up.

With lower temperature and well reduced night temperature the heads get firm and may keep long before they run to seed.

415. The writers describe the technique and results of their experiments in the identification of wood-destroying fungi by means of the temperature responses of the mycelium. Of the closely related pairs of fungi used in the tests, Lenzites sepiaria and Trametes protracta made the best growth at approximately the same temperature, viz. between 30°C. and 34°C., but the upper limits for development were different - 40°C. for L.sepiaria and 38°C. for T.protracta. The former also made much more rapid growth at all temperatures, especially from 28°C. to 36°C. These data are considered to support the generally accepted view that L.sepiaria and T.protracta are distinct species. Similar evidence was obtained in the case of Fomes roseus and T.subrosea, the optimum temperature for the former being about 26°C. and that for the latter approximately 30°C. F.roseus was also found to possess a lower moisture requirement than T.subrosea.

416. This is a detailed description of experiments carried out in the Saratov Government to determine the resistance of various pests to cold, with particular reference to the larvae of Euxoa segetum, Schiff. Existing literature on the effect of low temperatures on insects is briefly reviewed. Experiments with the larvae of Nygmia phaeorrhoea, Don. (Euproctis chrysorrhoea, L), Melolontha hippocastani, L., Plagionotus arcuatus, L., and E.segetum, the eggs and larvae of Locusta migratoria, L., and the adults of Scoliopteryx libatrix, L. and bees, showed that resistance to cold depends on the quantity

of

of fat and free water contained in the bodies of the insects, those containing more fat freezing less readily. While the insects are preparing for hibernation, the amount of free water in their bodies, which freezes very easily, is reduced. The lethal freezing-point of the hibernating stage of an insect depends entirely on the ecological conditions in which the particular instar lives and on its age at the moment of freezing. Any change of ecological conditions kills hibernating insects, whether they are prepared to withstand the cold or not. A temperature of - 11.1°C. killed all the eggs of L. migratoria in damp soil, while in dry soil only 76 per cent. were destroyed; a temperature of - 17.35°C. killed all the eggs in both instances. The resistance of the eggs of locusts in nature to very severe winters can be explained by the fact that the thick layers of snow prevent the temperature of the soil from falling to a point low enough to kill them. The critical temperature for larvae of this locust is - 2.9°C. if they are exposed to it for not less than 6 hr. All the larvae died within 2 hr. at a temperature of - 5.75°C. Early morning frosts do not affect young larvae, as they can withstand a temperature of - 3°C. for 3 hr.

Laboratory and field experiments showed that in the region of the lower Volga, larvae of E. segetum are killed by autumn and winter cold. The lethal point for larvae hibernating in the upper layers of the soil is a temperature not lower than - 5.75°C.; for those in deeper layers it is between - 7.8°C. and - 11.1°C. Owing to the fact that the larvae freeze under the severe temperature conditions of this region, the damage done by this pest is slight. It can be abundant only in places where there is a sufficient layer of snow during the winter to protect the soil from freezing, and where the winter is not severe and long. In the region discussed, however, snow falls only in the second half of the winter.

417. *Thermal constants for beginning emergence and maximum emergence of the overwintered generation and the first summer generation of codling moth (Cydia pomonella, L.), determined by summation of day-degrees of effective temperature, exhibit a sufficiently small amount of variation from year to year to render them satisfactory indicators of time when insecticidal applications should be made for the control of the larvae of that insect entering apples, but the dates, as determined by the thermal constants should be checked against the codling moth bait pan records in order to make sure that the season in question does not exhibit some unusual type of variation. While the dates of beginning emergence and maximum emergence of the overwintered generation and the first summer generation seem to vary according to the latitude and altitude phase of the bi-oclimatic law, the writer feels that further data should be secured before dependence is placed upon this principle for determining the dates of insecticide applications. When the average weekly minimum temperature (in late summer or early autumn) approaches 60°F., codling moth transformation from larva to pupa ceases. It is probable, however, that the determination of this tendency of larvae to pupate occurs under a somewhat higher average minimum than 60°F., and it seems, in the writer's experience, that this determination of tendency takes place before the larva starts to spin its cocoon.

418. In connection with soil temperature studies with cotton the author investigated the relation of temperature and moisture of soil to the sore shin disease of cotton caused by Rhizoctonia solani.

The maximum, optimum and minimum temperatures for the growth of the fungus were determined. The maximum temperature for growth in cultures was found to be about 38°C. with an optimum temperature between 27°C and 29°C and a minimum between 7°C and 11°C. The optimum temperature range for killing cotton plants was between 17°C and 23°C. No minimum was determined as the cotton seed failed to germinate below 15°C but the maximum temperature at which cotton plants were killed was about 34°C. It is claimed that any degree of soil moisture which permits the growth of the cotton plant is sufficient to allow Rhizoctonia to attack cotton plants if the soil temperatures are favourable.

Several strains of Rhizoctonia were studied and one isolated from cabbage was practically nonparasitic on cotton, while a strain of the fungus from potatoes was nearly as virulent as those isolated from cotton plants.

419. *This is a line survey of the vegetation, especially the grassland, along the road from Sirur to Lonavla in the Bombay Presidency. The annual average rainfall at Sirur is 20.96 in. and at Lonavla is 166.74 in. The dominant grass species are markedly different at the two extreme stations, the change in the vegetation being seen near Kamshet where the rainfall is about 44 in. Kamshet marks approximately the boundary between thorn forest and monsoon forest.

420. *Customary methods of forecasting crop yields are based on the exercise of judgment and are subject to errors inherent in judgments, especially to bias. Hence methods involving the least possible exercise of judgment are needed, if only as checks upon current methods.

Forecasting yields from the weather would satisfy this need. Proposed methods assume that a given crop plant in a given region always reacts in the same way to a given kind of weather. Mathematical formulae have been developed to predict crops in a given year from weather and crop data of earlier years, and weather data of the year in question. Sometimes such forecasts are reasonably good, sometimes not. They would be better if data for past crops were not often inaccurate; if weather data, though reasonably exact, did not sometimes lack important weather factors; and if more were known of the laws of growth and of the influence of environmental factors on crop formation.

To remedy these deficiencies, crop yield statistics and weather records must be improved, and much scientific research upon the laws of plant growth must be conducted. Investigations by physiologists designed especially to determine at what stages of the crop plant's growth the weather exerts the greatest influence, and why, will prove particularly important. If these various gaps in knowledge are filled - and there is no reason why they cannot be - forecasting yields from the weather should become a valuable tool for agricultural statisticians. In all probability the process

must

must always depend in part upon statistical analysis. Experimental work promises to make its greatest contributions toward the problems of forecasting by furnishing improved bases for statistical analysis.

421. The following are the climatic zones of the Gold Coast:-

1.	Coastal Savannah	Sudanese zone.
2.	Deciduous Forest)	
3.	Wet Forest)	Guinea zone.
4.	Transitional)	
5.	Parkland and Inland Savannah	Sudanese zone.

Agricultural crops of importance occur mainly in the Guinea or Wet zone and are cacao, cola, coffee, oil-palms and rubber. The main products of the Sudanese or Dry zone are shea-butter, sisal, cotton and copra. Of the 5 main agricultural exports from the Gold Coast, 4, cacao, cola, palm-oil and kernels, and rubber come from the Guinea zone and one only, viz. copra from the Sudanese.

There are 15 Meteorological Stations in the Gold Coast distributed as follows:-

Coastal Savannah	5
Forest Area	6
Transitional	2
Inland Savannah	2

These are all stations of the Third Order except that only two have barometers but all have solar maximum and grass minimum thermometers. Daily observations are made at all stations, at 9 h. G.M.T. It is hoped in the near future to make 5 complete stations of the Second Order at least and to make the Headquarters Station a First Order Meteorological Observatory where research work may be undertaken.

There are 68 rainfall stations, including the 15 meteorological stations. The majority of the rainfall stations are situated in the forest area, which is most important since it is the cacao growing country. Much cacao is grown on the Gold Coast in districts where the rainfall is deficient or defective in distribution, but it appears able to survive, in more or less productive condition, owing to the high relative humidity of the air.

There is a separate chapter in the bulletin on Meteorology and Agriculture in the Gold Coast.

422. *The best temperature for the storage of sugar cane is 8°C. to 10°C. The cane should be packed in some material that will maintain its moisture content.

The cold storage of sugar cane seed as a regular plantation practice is not practicable. At a continuous temperature of 3°C. the seed cane is injured to such an extent that it will not germinate, although it may appear sound and fresh. Most of the fungi that cause damage to seed cane will grow well at 12°C. and some of them at 7°C. At a temperature as low as 6°C. there is development of the roots and buds of the sugar cane.

The

The freezing-point of the juice of sugar cane is about - 1°C.

Seed cuttings of Louisiana Purple will not germinate after exposure to a temperature of - 2°C. to - 5°C. for more than 80 min. P.O.J.213 germinated after exposure to a temperature of - 1.5° for 105 min.

423. It is known that Scab is a disease of a bacterial nature and is caused by Bacterium Savastanoi, E. F. Smith. Our enquiries show that infection is liable to occur when traumatic action of any kind opens the way through the protective tissues to the penetration of the pathogenic bacteria. The predisposing cause is to be found in the low temperature of the past winter, and very probably in the exceptional cold spells in our region a few days before Christmas. The temperature during this period suddenly fell to 5 degrees below zero after a very mild autumn.

An unexpected frost, especially when the plant is not completely dormant, causes the death of groups of cells of the bark and wood. At the re-awakening of the vegetation the living part of the wounded branch grows but the dead portion cannot keep up with this growth and being rigid splits in half and so forms in consequence a longitudinal fissure.

It is very difficult to establish at what temperature the olive freezes. Differing conditions of the vegetation in the vicinity have a great influence on it. Moreover, differing sensibility of particular tissues and of different parts of the same tissue to the action of cold depends, according to Prof. Petri, on the differing concentration of cell sap, the greater or lesser carbo-hydrate content which lowers markedly the point of precipitation of the albumunoids of the cytoplasm, precipitation which is caused by the concentration of the saline solution of the cell sap following on the subtraction of water produced by the frost.

424. The author discusses and criticises at length the theories expounded by Janisch on the mathematical expression of the influence of external factors (temperature, in this instance) on the development of insects.

425. This is a note presented at the meeting of the Société Météorologique on the 8th November, 1927. It deals with experiments on various types of herbage over which a thermometer can be placed and recommends, as a very suitable plant, Sagine subulee known in England as Pearlwort.

426. Chatin found that rainfall almost always contained iodine, from which it was concluded that it was always present in the air. Th. v. Fellenberg was the first to demonstrate the presence of iodine in dew. This investigator found the

following

following in dew deposited over night at Berne.

		γ Iodine in 1 litre of dew.	γ Iodine per sq.m. of soil surface.
28th Sept.1923.	Free Iodine	1.35	0.19
	Iodine in combination	5.57	0.80
17th Oct. 1923.	Free Iodine	1.00	0.08
	Iodine in combination	3.80	0.30

Fellenberg also found the iodine content of the air to vary from 0.03 γ per cu.m. to 24.54 γ per cu.m. and that the iodine content of the air at any one place can vary greatly. After heavy dews, followed by evaporation, the content in the morning air is large, but decreases towards midday. The concentration is highest at soil level, decreasing upwards. The air takes iodine from fresh and salt water and also from the soil.

Fellenberg found the iodine content of 1 Kg. of snow to vary from 0.045 γ to 1.90 γ and per sq. metre of soil surface to vary from 0.42 γ to 12.7 γ, and the iodine content of rain in Berne to vary from 0.26 γ per litre to 2.22 γ per litre (0.6 γ per sq.m. to 13.7 γ per sq.m.) in the outskirts of the town and from 0.27 γ per litre to 5.34 γ per litre (2.2 γ per sq.m. to 6.8 γ per sq.m.) in the town itself.

Hoymann in Holland found the following iodine content in rain:-

Distance from sea.	East Wind	S.W. Wind	S.W. Wind	S.W. Wind	S., S.W. & W. Wind
	γ J	γ J	γ J	γ J	γ J
440 m.	1.9	5.3	16	2	4
3 Km.	-	3.7	11	1	4
6 Km.	1.1	5.8	10	4	3

These figures show only a weak relationship between iodine content of rain and distance from sea. Also the opinion that iodine is obtained by the air from the sea is not substantiated. With continuing rain the iodine content of the rain decreases from day to day, but quickly increases again in fine weather. In the interior of a town the iodine content of the air and rain is much increased by coal smoke. Fellenberg found that the iodine organically combined was considerably increased. The proportion of inorganic and organic iodine was considered by Fellenberg as a measure of the purity of the atmosphere.

Sea water was found to be much richer than river water in iodine. Inorganic iodine is quickly taken up by plant organisms, notably plankton.

427. *The effect of X-rays on growth and development is a subject which has always caused considerable interest. It can be studied most easily in plants where cell division takes place so rapidly that daily growth can be observed.

We

We irradiated various kinds of seeds, chiefly broad beans, barley and mustard, the effects on these forms being dissimilar although the conditions and the dosage were exactly alike. It would appear, therefore, that a specific dose is required. We used approximately 3 times the dose of X-rays which would cause the human skin to redden, at 120 kilovolts. In every case the seeds were covered with black paper to protect them as much as possible from the light and heat from the tube.

The broad beans gave the most rapid and striking results. Seeds which had been planted for different lengths of time, varying from one week to a few hours, and also dry seeds, were employed, an equal number of seeds in each case being used as controls. Stunting following irradiation in all those which had been growing for more than 24 hr. The changes were not observable for some days (2 or 3) and were first seen in the oldest seeds, but beans which had been growing for 48 hr. to 72 hr. appeared to be most sensitive. In addition to being stunted the roots appeared to become slightly bulbous at the tip. In most cases the shoots appeared later than in the controls, but sometimes failed altogether. Side roots never appeared in the stunted X-rayed specimens.

In mustard seedlings the only detrimental result was the failure of the side roots to develop, and that only in the seeds which had been growing for more than 72 hr. before they were irradiated. An extremely small dose (about 1/20th of above) appeared to cause more rapid growth.

Little alteration was found in the roots of the barley, as in this plant the shoots were most radio-sensitive and showed very much less growth than the controls.

428. *Spores of 27 miscellaneous species of fungi were exposed for one min. to ultra-violet radiations from a quartz-inclosed mercury tungsten arc at a distance of 6 in. There was complete killing of the spores of 16 species, a survival of less than 1 per cent. in the case of 4 species, and survival ranging from 2 per cent. to 53 per cent. for the remaining 7 species. Mycelium from germinated spores was more easily killed than the resting spores.

The killing effect of ultra-violet rays is increased with the lengthening of the time of action and also with the increase in the intensity of the radiation. Decrease in the distance from the source of radiation results in increase in intensity and in consequent killing effect. An exposure of 5 sec. at 6 in. was sufficient to kill at the rate of 907 out of 1,000 spores of Penicillium digitatum. With an exposure of 45 sec. the rate of killing was 998 out of 1,000. It is supposed that partial shading of some of the spores accounts for the accidental survival of a few.

A series of short exposures has almost the same effect in a cumulative way as one continuous exposure of equal total duration. Penicillium spores on the surface of citrus fruits can be killed in large proportions by intermittent short exposures to ultra-violet rays.

The ultra-violet rays in the dosages used did not cause any apparent injurious effect on the oranges.

In holding tests, decay of inoculated oranges was only

moderately

moderately retarded by applications of ultra-violet rays that seem to reach the limit of economical practice under present conditions for time of exposure and distance from lamps.

The principal physical limitations to the use of ultra-violet rays for complete disinfection of fruits seem to be their inability to penetrate much if at all below the surface, so as to destroy mycelium that may have started infection already, and the accidental shading effects that favour the survival of some of the contaminating spores.

The shorter wave-length components of the ultra-violet spectrum have the greatest fungicidal action. The longer wave-lengths of this spectrum, such as are components of sunlight, have relatively weak fungicidal power, and require greatly prolonged exposures for the killing effect.

429. The object of this note is to record briefly the results of experiments upon Saprolegnia ferax carried out during the summers of 1925 and 1926 at Woods Hole. It was to be expected that with modern radiation apparatus and a knowledge of the technique as applied to Drosophila, Saprolegnia with its extremely sensitive behaviour toward chemical changes and its various modes of reproduction would provide changes under the action of X-rays which could be treated statistically. Except for a possible stimulus to nuclear division in the mycelium under the influence of X-rays, extensive experimentation on the rate of growth in culture media, on the formation and liberation of zoospores, the formation of oogonia and oospores, and the movement of protoplasm, failed to produce any results which could be attributed to the action of X-rays. The amount of radiation was enormously greater than had been employed with Drosophila. A dosage of 50,000 volts at 2.5 m.a. for 20 min. with a standard Coolidge tube, and the material at 12 cm. from the tungsten target had been sufficient to cause complete sterility in Drosophila for 2 days and partial sterility for 10 days. Applications as high as 75,000 volts at 10 m.a. for 45 min. at a similar distance from the tube failed to produce any results in Saprolegnia. The material radiated was exposed in water in small petrie dishes, duplicate material being kept at a control. The entire life-cycle of Saprolegnia may be carried out in from 2 to 3 days. These experiments were so conducted that samples of the radiated material could be removed for study or staining without disturbing the remaining material. It was desirable to keep a large amount of material permanently, and after experimentation with many stains it was found that gentian violet for 18 to 24 hr. destained by xylol, would show chromosomes in the mycelium and the oogonia without recourse to sectioning. The chromosomes, however, are minute.

430. The author describes experiments carried out to discover whether cattle, as kept on the average farm, would benefit by exposure to the rays of an ultra-violet ray lamp.

The cattle were from 7 months to 9 months old when the first experiment commenced, at the end of October, 1926. The dams were cross Shorthorn cows, and a pedigree Aberdeen-Angus bull was the sire of two of the calves, the remaining four having been sired by a pedigree Shorthorn bull. The calves were weighed and divided into two groups, one Aberdeen-Angus and two Shorthorn crosses in each group, selected according to weight and sex, each group including one heifer. The total weights of each group showed a difference of only 6 lb.

Both

Both groups were housed in one small cattle court with stone walls and a corrugated iron roof with lights of ordinary glass, and were divided by a sparred fence. One group was irradiated daily, by means of a 500 Watt mercury-vapour lamp, starting with an exposure of 10 min. The length of the exposure was increased by 10 min. daily to 1½ hr. After a month the exposure was increased to 2 hr. The control group were shielded from the rays by means of a metal shade.

Both groups were fed similarly and were weighed every fortnight before the morning feed. By the middle of April,1927, when the experiment ended, the irradiated group was 83 lb.ahead of the control.

The result was not held to be sufficiently definite and the experiment was repeated the following winter.

This time there were four beasts in each group. All were Aberdeen-Angus crosses except one, a roan Shorthorn cross which was in the non-irradiated group. There were two second cross Aberdeen-Angus - Highland calves, and one was placed in each group. There was a difference of 12 lb. between the total weights of each group when the experiment commenced on the 15th November, 1927.

This time the first exposure lasted 5 min. and the length of exposure was increased 10 min. daily to 1 hr. During irradiation the four beasts were shut in an inner division, 13 ft. by 9 ft., and thus kept fairly near the lamp.

Weighings were carried out as before. The irradiated group fell behind steadily and by the 1st April, 1928, the difference in weight was 92 lb. in favour of the non-irradiated group.

The results of the two experiments appear contradictory but this may be due to the chance group of the cattle.

The author suggests that the results seem to indicate that exposure to ultra-violet rays without the other accompanying benefits of natural sunshine is not of value to cattle kept under ordinary farm conditions and fed on the average farm rations.

Reference is made to the experiments of various workers and mention is made of the possibility of cattle receiving the benefits of sunshine by means of their food even though they themselves are not exposed to the direct rays of the sun.

431. The green leaf may be considered as a heat engine the source of heat of which is formed by the chloroleucites and the cooling by the air which circulates in the free spaces of the parenchyma and which acts as a condenser by absorption. The activity of the plant follows regularly neither the outside temperature nor the intensity of light. It obeys, rather, specific factors which vary from one species to another. The effects of these factors can be determined by the differences of temperature noticeable, even to the touch, among leaves of different species placed under the same environmental conditions.

432. The germination of seeds requires as a primary condition the penetration of water from outside for the hydration and hydrolysis of the reserve material. Deprived of their husk, seeds germinate more rapidly. Beans with and without their husk have been placed in tubes at different temperatures. At 27°C. the cleaned beans germinated about the 2nd day; the intact beans did not germinate before the 8th day. At 15°C. both kinds germinated in 8 days. Variations of temperature are favourable and necessary for the growth of certain seeds like those of the peach.

433. This important work is divided into two parts. In the first, which is a critical review of the work of a number of physiologists who have studied the action of cold on vegetation, the authors frequently mention the results of their own experiments and they consider the following points:-

(a) The formation of ice in the vegetable tissues and the part played by this formation in the killing by cold;

(b) The chemical means of protection against killing occasioned by the formation of ice;

(c) Internal factors which influence the resistance to cold;

(d) Correlations between the resistance to cold and other properties of vegetable tissues.

From this summary it is concluded that as a general rule killing by cold is the consequence of a too large formation of ice in the tissues.

Every cause tending to prevent the formation of ice constitutes in consequence a means of protection of the plant, and, among the internal factors capable of playing this part of protector, particular attention should be given to the simple sugars which one normally finds during winter, in vegetable tissues.

In the second part, the authors show what use practical crop improvement can make of the theoretical research which they have just reviewed.

They describe a series of experiments made at Svalof and at certain co-operating stations to determine the capacity for overwintering of the varieties of wheat grown in Sweden; experiments leading to a classification of Swedish wheats from the point of view of their winter resistance. These trials confirm the opinion of Nilson Ehle that in Sweden the principal cause of failure of winter wheats is to be found in the action of low temperatures during the winter months and not, as is commonly supposed, in the cooling or the alternation of relative heat and cold which the plants suffer at the beginning of spring.

This is important because, if cold only is the cause, it is possible to judge rapidly and conveniently the overwintering capacity of varieties by submitting them to the action of artificial cold. The authors prove this in a second series of experiments in which they subjected the

Swedish

Swedish varieties of wheat to the action of artificial cold. They were led to a classification of varieties identical to the first, but they point out that for such experiments it is necessary to use plants which have sprung up at low temperature if one wishes to adjudge the varieties with certainty. They state in effect that resistant varieties taken in spring, after the awakening of growth, and carried to the cold chamber are then nearly as badly damaged as non-resistant varieties. The period from November to January, that is when the plants are not growing but have not yet been subjected to too low temperatures, is the best for these experiments and it is necessary to take care to use plants of the same vigour and at the same stage of development.

The authors show that there exists a perfect correlation between the overwintering capacity (established by experiments in the field), the resistance to cold (established by means of a cold chamber) and the sugar content of the different varieties of wheat during the winter. The differences in resistance to the winter are shown in the differences in the same sense in the sugar content. Here again it is necessary to avoid making the analysis on plants in course of growth; on the other hand, only those plants should be used which have been already subjected to relatively low temperatures, but have not been subjected to the rigours of cold.

Lastly, Akerman deduces from microscopical examination that there is equally correlation between the osmotic pressure and resistance to cold.

The experiments of Akerman and Lindberg were not carried out solely on the varieties actually grown in Sweden, but also on hybrids still on trial. The authors establish that the types richest in sugar are also the most resistant to cold and consequently to the winter, and that variations towards a greater sugar content are shown also by a greater winter resistance.

434. Nitrifying bacteria strongly resist desiccation equally in artificial cultures as under natural conditions. The author of this paper has tested whether resistance is equally shown to the effects of very high temperatures. At 55°C. to 60°C. the number of bacteria diminishes rapidly and the capacity for the fixation of nitrogen diminishes. After 39 days exposure to this temperature the bacteria themselves disappear completely. Earlier experiments have proved that the activity of nitrifying bacteria, suspended by exposure to heat, can be re-established in favourable conditions and for a soil moisture content of 60 per cent. especially when a certain quantity of "mannite" is added to the soil. The author concludes that the resistance of the bacteria to drying is unlimited but that, on the contrary, its resistance to heat is much less strong. In soils which in summer are subjected to high temperatures its activity will be therefore diminished but the presence of nutritive matter and a suitable humidity will revive them rapidly.

435. *The investigation bears out the conclusion of the Rothamsted experiments that leaching may occur any time throughout the winter up to March, or rarely, April.

The loss of nitrates is directly limited by the amount of drainage and so is indirectly determined by the rainfall, and by temperature - as it affects the rate of evaporation.

All three nitrogeneus fertilisers are shown to lose well over 50 per cent. of a normal dressing by leaching during the winter, but the loss is greatest in the case of sulphate of ammonia, least in the case of rape dust, calcium cyanamide being intermediate.

436. Experiments with artificial shading of tomato plants, which tended to lower the rate of evaporation, reduced the amount of yellows (formerly known as western yellow blight). While some of this reduction under field conditions may have been due to the protection of the plants from beet leafhoppers, instrumental in spreading the infection, it was also attained in cases when tomatoes were artificially inoculated and then shaded. Inoculation tests conducted simultaneously under different habitats show very definitely that light is of primary importance in the progress of tomato yellows and correlates very closely with the rate of evaporation. However, indications are that low relative humidity also favours the disease to a certain extent. The total intensity of light during these experiments was measured at various times by the uranyl acetate-oxalic acid method. The effect of reduced light was four-fold; (1) the incubation period in the host was prolonged; (2) the plant growth was accelerated; (3) the disease symptoms took on a milder form; and (4) the percentage of yellows was lower.

437. The method suggested in this paper for arriving at a graphic representation of the relationship existing between the distribution, extent, and intensity of outbreaks of plant diseases and insect pests, on the one side, and variations in climatic conditions (temperature and rainfall), on the other, is based on the use of special charts proposed by Ball about 1910 and first applied in practice by Taylor in 1916. These charts, termed hythergraphs, are in the form of graphic diagrams, the vertical and horizontal scales of which usually represent temperature and rainfall, respectively, and any combination in the measurements of these two factors is determined by the intersection of the corresponding ordinate and abscissa in the usual way. In its simpler form, a hythergraph thus consists of a series of points which markccombinations of temperature and rainfall for successive days or for longer periods, and it is often possible to show the general trend from one to another of these points by an ordinary graph of connecting lines. A more complicated form is constructed by plotting a considerable number of mean temperature and total rainfall combinations for stated periods, such as months or years, or for determined localities or regions. By joining the plotted points with straight lines, it is then possible to determine the particular range of the climatic conditions associated with a given phenomenon (in the present case disease or insect outbreak) or with certain degrees of its manifestation, as indicated by correlative data. The result is usually one or several irregular polygons which may be rendered more inclusive, and probably more indicative, by smoothing them by means of mathematical formulae or, when the data are sufficiently abundant, by the use of the draughtsman's French curve. The resulting lines, called 'isopracts' by Huntington,are roughly circular, elliptical, or ovoid, and are usually eccentrically arranged. These two types of graphs may often be combined advantageously to show not only the ranges but also the trends of the two factors considered in the course of months, seasons, or any other desired period associated with the phenomenon studied. For the sake of brevity, the author suggests two new terms, namely, 'thermohyet' to designate the

combined

combined datum consisting of a record of temperature and rainfall and, by analogy, any point in the hythergraph representing this record; and 'thermohyetic' to serve as an adjective instead of the more unwieldy expressions 'temperature-rainfall', 'mean temperature - total rainfall', and the like.

The use of the hythergraphs is illustrated by their application to the study of the relationship to weather conditions of late blight of potatoes (Phytophthora infestans), of the beet leafhopper (Eutettix tenella) and curly top of sugar beet, and of the cucumber beetles (Diabrotica vittata and D.duodecempunctata) and bacterial wilt of melons (Bacillus tracheiphilus). The comparison of hythergraphs constructed on Martin's data for potato blight in New Jersey, where epidemics are relatively frequent, and for four northern stations of Illinois, where the disease occurs sometimes in mild epidemics but is usually absent, showed that the normal thermohyets for the latter, while outside the isopract for mild destructiveness of the blight in New Jersey, lie so close to the boundary that slight variations from the normal in temperature and rainfall during the critical period are sufficient to render the development of an epidemic not only possible but to be expected. In the case of curly top of sugar beet, the indications obtained by the use of these graphs are that the growing season of the plants is the period of most consequence in respect of the disease, whereas other periods of the year, more especially the hibernating period, are of greater significance in regard to the leaf-hopper carrying it. By way of further illustration, the author describes and discusses in detail a modification of the hythergraph as applied to the study of the correlation of the destructiveness index of wheat rust (Puccinia triticina) to the mean temperature and total rainfall in rust years in Illinois, no conclusion from which is, however, drawn. A new feature in this study is the attempt to represent this correlation in a three dimensional graph, in which the isopracts for destructiveness of the rust are used in the same way as contour lines are employed by physiographers to show differences in altitude on plane surface maps.

438. This quarto of 50 pp. includes a single page of introduction (in English) followed by 46 pp. presenting in tabular form data for some 1,400 flowering plants out of 2,000 in Mr. Moe's original records, now deposited in the University Botanical Museum in Oslo. For each plant are given records of the day of the month it was observed each year, and the resulting average date. Presumably the latter are weighted for missing years, which amount in some dozen or twenty cases to all but four or five. The tables must embrace well over 20,000 records. With rare exceptions, shown by block type, the plants flowered in the author's own garden. Perhaps one-third are native to the district. Needless to say, such a series puts his work in the first rank of similar compilations; probably it is unique. Moreover, it opens up a new area, the nearest long series, covering ten years or more, coming from Copenhagen. Our own country can muster three; one by Gilbert White of Selborne; another by Rev. Leo Jenyns of Swaffham, a century later, begun in 1820; and the unique school record of Marlborough College, begun in 1865. Our own series does not vie with the above as to the number of plants observed, its object being so different.

Such a monumental work, apart from its local values for farm and garden, is of prime scientific value. For it greatly extends the means of studying the relative effects of

diverse

diverse weather conditions from region to region and from plant to plant. Naturally, to illustrate this on the small scale of a brief notice, we take for comparison our own series of fourteen plant records. All these appear in the Stavanger list except blackthorn, garlic hedge mustard, greater bindweed and ivy, every month from February to August being represented.

Plant.	British Isles average 1891-1925.	Stavanger average 1897-1926.		Difference, Stavanger- B.I.
Hazel (C.avellana) (female)	13.II	23.III		+ 38 days.
Coltsfoot (T.farfara)..	5.III	10.IV		+ 36 "
Anemone (A.nemorosa)...	I.IV	11.IV		+ 10 "
Horse-Chestnut (AE.hippocastanum)..	13.V	29.V	+16 days.) av.	+17½ "
Hawthorn (C.oxyacantha)	19.V	7.VI	+19 ")	
White Ox-eye (C.Leucanthemum) ...	3.VI	16.VI	+13 ") av.	+11½ "
Dog Rose (R.canina) ...	12.VI	22.VI	+10 ")	
Black Knapweed (C.nigra)	9.VII	1.VIII	+23 ") av.	+6 "
Harebell (C.rotundifolia)	11.VII	30.VI	-11 ")	
Devil's-bit Scabious (S.succisa)...	6.VIII	3.VIII		- 3 "

Very striking are the contrasting effects of climate; the Stavanger plants are mostly later than the corresponding plants in the British Isles, but there is a constantly lessening difference (except for the anemone) from over a month during the winter rigour to actual earliness when the insolation of long summer days has had its full effect.

439. A fall in temperature from 26°F. to -25°F. in the early winter of 1927, after a slight fall of snow that left many places exposed and followed by a rise to -8°F. caused 100 per cent. mortality among Hippodamia convergens, Guer., in Iowa, where the average annual minimum temperature is -10°F. Other Coccinellids, including two species of Hippodamia, were found active among the dead H.convergens, which was rare the following spring, whereas the other species of Hippodamia were quite common. An exhaustive survey of an asparagus bed infested with Crioceris asparagi L., effected on the day following the period of extreme cold, revealed an almost total mortality. Most of the beetles were hibernating in the first 12 in. or 14 in. of the decayed organic material along the fence rows, and some were sheltering in hollow asparagus stalks, having apparently entered by the path of a previous insect or at broken internodes, without themselves boring into the stalk. Examination of stalks revealed infestation of this type varying from 22 per cent. to 52 per cent. Anthicus spp., which were often collected in company with C.asparagi, always showed activity on being disturbed. An examination of isotherms showing the average annual minimum temperatures prevailing in the United States indicated a relation between them and the northern limit of C.asparagi and certain other insects.

440. *Normal healthy potato seed stocks produced in soil at different temperatures and of varying moisture content and texture were planted in the field to determine whether (or to what extent) such environmental factors exerted an influence upon their productivity.

It

It was found that while the soil temperature did materially affect the shape and colour of the seed tubers it had no significant influence upon their productivity.

The yields from seed stocks produced upon soil containing high, medium and low amounts of moisture were not sufficiently different to be of statistical importance.

While soil texture had a very pronounced effect upon the appearance of the tubers produced, no definite and consistent effect upon the yield produced from those tubers could be deduced from the results of the comparative field trials.

441. *The problem of the use of water by cultivated plants in the field was first undertaken for study on the experimental field of the Field Husbandry Department at the Saratov Experimental Station. Two years later it was studied at six experimental stations of Nijnee Povoljie. The purpose of this collective experiment was to determine the character and the amount of the use of water by different plants under different weather conditions and on different soils.

The use of water was established by means of the determination, every ten days, of the water content in the soil beginning after sowing time and ending at or near harvest. The total quantity of precipitation during the period of growth was added to water lost from the soil during the period between the first and the last observation on soil moisture. The increase in the dry weight of the plant was determined at the same time. The total weight of water used from the soil (together with rainfall) was then divided by the dry weight of the crop, thus establishing the quantity called in this study "transpiration co-efficient".

This investigation has enabled us to draw the conclusion that the total quantity of water used in any year by different plants during their growth in different parts of the region and on different soils is more or less uniform. It depends to a considerable degree on the quantity of precipitation during the growth period and is, therefore, larger in moist years. When distinguishing in this total quantity the water used from the supply stored in the soil up to the time of sowing, and water supplied by rainfall during the period of growth, it should be noted that in dry years the larger portion of the plant's total requirement in water is obtained from the water supply stored in the soil, and vice versâ. The comparison of different plants, in that respect, shows that to plants with a long period of growth the largest portion of their requirement in water is supplied by rainfall during the period of growth. The transpiration co-efficients of different plants in the same year differ rather considerably from each other. In a dry year they are considerably higher than in a moist one. They are likewise considerably higher for early crops and beans and considerably lower for winter rye and wheat, corn, sorghum, Sudan grass, millet and potatoes. Or, stated in another way, they are lower for the plants with a long period of growth. From all parts observed at different stations during the period of three years the most exigent was spring wheat. It has most often the highest transpiration co-efficient. The lowest transpiration co-efficients have been shown more frequently by corn and winter rye.

The investigation confirms with sufficient precision the fundamental importance of the initial water supply stored in the soil for the plants with a short growth period as well

as

as its considerably smaller importance for the late plants. It was not possible to determine any specific importance of the different types of soils at different experimental stations.

442. *Figures have been obtained at Cheshunt during the past eleven years which suggest an intimate connection between the weight of the tomato crop and the amount of bright sunshine occurring during the season. The curve of annual crop yields from 1917 to 1927 inclusive follows the same trend as the curve of total hours of bright sunshine from 1st April to 31st August inclusive. While rainfall and temperature undoubtedly affect the total weight of crops produced, they are not so important as bright sunshine during these months.

Records from plots receiving various manurial treatments suggest that prolonged sunshine has a similar effect on the plant to that produced by potash manures. The crop thus requires less potash in fine sunny summers than during dull weather.

443. Studies at the Boyce Thompson Institute for Plant Research on the storage of parsnip seeds indicated the advisability of thorough drying followed by storage in air-tight containers held at moderate temperatures. Temperature and humidity were both important factors in parsnip seed storage, but of the two humidity is deemed the more important. With moisture content high temperature should be low, and reciprocally with temperature high moisture content must be at a minimum. As a result of the study two methods of storing are recommended - (1) at ice-box temperature, approximately 5°C., and (2) at ordinary storage temperature, preceded by a thorough drying of the seeds at 90°C. for from 4 hr. to 6 hr. and subsequent storage in air-tight containers.

444. Results of observations extending over several years on the temperature of fallow land at the surface and at depths of 5 cm.,10 cm.,15 cm.,20 cm.,25 cm. and 30 cm. and on cropped soils at the surface and at depths of 5 cm.,10 cm.,20 cm.,30 cm. and 50 cm. are presented in text, tables and diagrams. The cropping consisted of a rotation of cotton, wheat, maize and berseem. The range of temperature decreased with depth. The mean range under wheat at depths of 5 cm.,10 cm. and 20 cm. narrowed during vegetative growth until the period of full ear, then steadily widened until maturity. The maximum temperature at all depths was higher under berseem than under wheat. The general effect of the crops was to lower soil temperature, and at a depth of 25 cm. the temperature during the fallow period after a crop did not rise as high as in the case of continuous fallow.

445. The precentage of dry matter in the tomato varies in inverse proportion to the percentage of humidity of the soil.

The largest amount, the greatest number and the highest development of the tomato corresponds to a humidity of 70 per cent. in the soil. It appears that the percentage of dry matter in the tomato considerably affects the unit price of the fruit sold on the basis of weight or volume.

446. *Sugar concentration in nectar was found to vary inversely with relative humidity. Correlation between these two factors was found to be much closer in some types of flowers than in others. The Abbe refractometer was found highly satisfactory for determining sugar concentration in nectar.

447. This study at the Hokkaido Imperial University is divided into 3 parts. The experiment reported in part I was a study of the influence of ultra-violet light when irradiated upon the rear and two sides of the udders of two cows for 30 min. daily at a distance of 25 cm. for a period of 9 days. A quartz mercury-vapour lamp was used in this test. It was observed that the irradiating process was quite soothing to the cows and that they ruminated slowly during the periods. The light also had a stimulating effect upon production. Cows so treated showed an increase of 4.77 per cent. in the amount of milk and 8.73 per cent. in the amount of butterfat produced over cows not treated. The treatment was also favourable to increases in body weight.

The experiment reported in part 2 shows that when the concentrated portion of the cow's ration was irradiated for 1.5 hr. per day at a distance of 60 cm. there was an increase of 2.92 per cent. in the amount of milk and 4.24 per cent. in the amount of butterfat produced. If, however, the corn silage in addition to the concentrates was irradiated, there was an increase of 28.4 per cent. of milk and 15.9 per cent. of butterfat.

448. Investigations conducted at the Pennsylvania Experiment Station are briefly reported which showed that there was a steady decrease in the moisture content of wheat and oats from 9 a.m. until 6 p.m. or even 7 p.m., even though the relative humidity began to increase after about 2 p.m. During different days the grain lost from 3 per cent. to 8 per cent. in moisture content, depending upon weather conditions, which was partially or wholly taken up the following night depending upon atmospheric conditions.

The daily loss in moisture content varied inversely with the average daily relative humidity. The moisture content of the wheat increased from 3 per cent. to 5 per cent. overnight from heavy dews, and 0.5 in. of rain at night increased it 8.3 per cent. No definite hour in the morning for starting the combine is indicated by these findings since it appears to depend entirely upon weather conditions.

449. Experiments conducted at the Virginia Experiment Station are briefly reported, the most outstanding result of which was the close relation found between the moisture content of wheat and the relative humidity. It appears that rainfall does not affect the moisture content of standing wheat except as it causes a change in the relative humidity.

450. *The contents of this paper indicate that weather has a marked effect on bark beetle outbreaks. A hickory bark beetle, Eccoptogaster quadrispinosus, outbreak occurred during the drought period of 1925 in North Carolina. The marked

deficiency

deficiency in precipitation weakened hickory trees by checking growth and rendered them attractive to beetle attacks, favouring brood development. An excess of precipitation during periods of beetle flight resulted in a partial mortality of the adults, thereby considerably reducing the number attacking and also rendered trees unfavourable for brood development.

451. It is pointed out that climatic conditions not only affect outbreaks of Lepidopterous pests in forests directly, but also indirectly through their food-plants and natural enemies. After describing the direct effects of weather on the pine Lasiocampid (Dendrolimus pini, L.) the author suggests that it has a similar influence on the nun moth (Lymantria monacha, L.).

The periodic outbreaks of these pests are not due to a lack of natural enemies, as formerly believed, but to climatic conditions. Dry, warm weather accelerates oviposition and the development of the eggs. In the case of D.pini cold and wet weather causes many of the caterpillars to hibernate twice. Oviposition, too, is delayed, and the caterpillars are weak, remain on the trees in autumn and are destroyed by the weather. Similar delays in larval and pupal development occur with the nun moth. In Saxony, near Zittau, an outbreak of the latter occurred in 1920-23, and a detailed account is given of its course. Egg development in 1921 was retarded in high-lying situations, but was finally completed. In the cold, wet year of 1922 up to 8 per cent. of the eggs were infertile at about 350 ft., and at 2,100 ft. they were all infertile, showing that no mating had taken place.

The author failed to find an indirect effect of weather through the food-plant in the case of D.pini, but this effect was observed in that of L.monacha. The nun-moth larvae always prefer the previous year's needles to young ones. The softer epidermis of pine needles, as compared with those of spruce, allows them to feed earlier on the old needles. For this reason, in cases of moderate infestation, the May shoots of pine are far less exposed to destruction than those of spruce. But as the epidermis of old pine needles is still too hard for the newly hatched caterpillars, an outbreak in pine forests is possible only in years in which the larvae hatch late and the shoots are early, otherwise most of the larvae die of starvation. In pine, the interval between the hatching of the caterpillars and the appearance of the shoots is far greater than in spruce.

In 1921 up to 32 per cent. of the larvae of L.monacha in Zittau were infested by the Tachinid, Parasetigena sylvestris, R. - D. (segregata, Rond.) but in 1922 the percentage was lower. In 1923 it was also moderate, but polyhedral disease was general. The development of beneficial species is favoured by warm, dry weather and hindered by wet and cold. But theeffect of weather is also indirect. Cold, wet weather may bring together the developmental stages of the pest and its parasite and thus benefit the latter, whereas warm, dry weather may separate them by a long interval.

452. The influence of the colloids present in the tissues upon the physiology of response and adjustment is here considered, and experiments are reported in which there appears to be a definite colloidal response to conditions of temperature and moisture.

453. *In addition to recording the daily changes in weight of a hive of bees on scales, beekeepers should also secure a daily record of weather data provided the Weather Bureau is not too far distant to be applicable. With these two sets of records the beekeeper will be better able to learn the factors which influence the yield of honey. A study of weather data and record of a hive of bees on scales, at the North Dakota Experimental Station, indicated that excessive rainfall, during the normal nectar flow period, was more responsible for decreased yield of honey than any other cause.

454. It is stated that the method of averages as used in the study of climatology is unsatisfactory in many respects, especially for practical purposes, and a method using frequency of occurrence of types is described. This is based on the fundamental idea that the climate of any place is an association of weather, the latter being considered as an indivisible phenomenon. Application of the method is illustrated in the climate of May and June at the Timiriazevskaia Academy, based on data for the 20 yr. 1892-1911. The problem of the influence of weather as a unit on the plant is discussed with reference of favourable and unfavourable types.

455. In view of the severity of the past winter in Germany, the effect of cold on insects is discussed, and it is pointed out that it is sudden, violent changes of temperature that prove fatal, as native insects can withstand extreme cold provided that the transition to and from it is gradual.

456. From 290 pot experiments with oats, mustard, poppies, peas, clover, and carrots on clay, sand, and bog soils in pure and mixed condition to show where soil moisture agrees as a growth co-efficient with Mitscherlich's "law of influence of growth factors", the conclusion is reached that the physical character of the soil exerts no specific influence through which water as a growth co-efficient might change in any way the productivity of the plant. Soil water as a growth co-efficient behaves precisely as any other growth co-efficient according to the "law of influence of growth factors". The bog soils differ slightly in this respect, probably because of their ability to absorb nutrient salts, and also because of the presence of certain toxic acids. The water co-efficient is 0.5150 in the case of oats, clover and carrots, and 0.3415 in the case of beans, peas, mustard and poppies.

457. This paper gives the results of a study of moisture as an ecological factor in the life of Epilachna corrupta, Muls. The native habitat of this beetle has a very wet climate during the summer, and it is a serious pest in the eastern United States, where precipitation is heavy. In the western States, infestation is largely confined to areas where the fields are irrigated, being rare and only occasionally injurious in other sections. The fact that drought periods in the east are nearly as disastrous to the bean beetle as normal precipitation in the dry farm areas in the west is also suggestive of a high moisture requirement on the part of the insect. This is apparently true

of

of all its stages and during the entire year. These conclusions are in direct contradiction to those of Graf.

458. Investigations have shown that neither full sunlight nor light of different wave-lengths exerts any direct influence on the activity of Melolontha melolontha. L. (vulgaris, F.) and other insects. Neither sunlight nor arc light produces in the air any gas that exerts a depressing influence on M.melolontha, and nitrous oxide has no effect. The only factor that has any appreciable effect on the activity of these insects is the humidity of the atmosphere (as influenced by temperature) and its effect on the rate at which water is lost by them. The hiding of insects during the day is attributed to the necessity for sheltering from the excessive evaporating power of day air (low humidity and high temperature), and their activity at night to a reversal of air conditions, night air being cooler and more humid.

459. The method used is the fading of a standard solution of pure acetone (30 per cent.) and methylene blue tested against standard tubes marked 3 to 10. Each degree of fading corresponds to twice the dose required for killing infusoria or producing erythema of the average white skin. As the ultra-violet rays come more from the whole skyshine on bright days than from the direct sun, the standard quartz tube containing the standard solution must be exposed to skyshine on all sides down to the horizon. The rays of the sunlight which fade acetone blue are shown by spectroscopic and other analysis to correspond closely with those which produce erythema and, by activating ergosterol, produce vitamin D. Records kept for 2½ yr. in various places show that the winter readings are much lower than the summer, that smoky cities do not receive half the ultra-violet rays received by clean country or seaside places, and that while Davos receives more than seaside places in England, Assouan in Egypt receives twice as much as Davos.

460. In many territories of Germany it has been common practice to begin hay-making on a definite date, irrespective of climatic season variations. Chemical analyses of grasses before, at, and after the blooming stage show that the time for this stage may vary considerably from one year to another, according to weather conditions. Observations made in 1926 at 75 different locations on the blooming periods of 19 different grasses and fodder plants are tabulated.

461. *The freezing-point of alfalfa root tissue was determined by the therm-oelectric method. In these tests there was little correlation between the freezing-points and the diameters of the roots.

There was a slight correlation between the freezing-points of sections of alfalfa taproots taken near the crown and similar sections taken 10 cm. below.

The average freezing-point of root tissue in or near the cambium was -2.11°C., while that of the centre of the root was -2.3°C.

No

No correlation was found to exist between the freezing-point and the known hardiness of the root tissue of different varieties of alfalfa.

x x x

The amount of cold which alfalfa roots can withstand depends upon their hardiness, the amount of insulation afforded by the substratum in which they are embedded, soil moisture, and other factors.

Roots of non-hardened plants with abundant carbohydrate reserves freeze less easily than roots of plants that have been deprived of light for some time. Presumably this difference is due to a change in the physiological condition of the cells brought about by a lack of root reserves.

It is shown by using the dilatometer method that a correlation existed between the amount of bound water and cold resistance of hardened and non-hardened plants. A similar correlation with respect to the known hardiness of different varieties, however, was not evident.

462. *The concentration of hydrogen ions in leaf juice of Hard Federation, Harvest Queen and Turkey wheats grown at temperatures of 12°C. to 18°C., 20°C. to 25°C., and 25°C. to 30°C., respectively, was found to be lowest at the low temperature and highest at the high temperature.

The medium-temperature plants of all three varieties grew most rapidly at first, and almost without exception had the lowest titratable acidity, specific gravity, and dry-weight percentages throughout their vegetative stages, or as long as the temperature differences in the greenhouses could be maintained. The high-temperature plants generally had the highest titratable acidity, specific gravity, and dry-weight percentages.

The magnitudes of the titratable-acid values were closely correlated with those of the measurements of specific gravity at all three temperatures.

The pH value reflected the degree of adaptability of each variety to the different temperatures. Those plants which were best adapted, as shown by their vigorous growth and development, had pH values near 6.0 throughout the experiment. Those plants which were so injured that they failed to develop beyond the shooting stage developed much higher hydrogen-ion concentrations, extreme injury being accompanied by values near 5.6 while the plants were still in a vegetative stage.

463. *This study concerns the relation of atmospheric and soil moisture to seed production of red clover.

Soil moisture, whether low, medium, or high, did not prevent the setting of red clover seed either when plants were grown in the field or under controlled conditions.

Medium soil moisture content when compared to low or high soil moisture content increased the productiveness of red clover plants with respect to both the number of heads and flower stems and vegetative growth. Plants grown in soil low

in

in moisture produced a greater number of heads and more vegetative growth than those grown in soil high in moisture.

Low soil moisture and high soil moisture were more conducive to early flowering and uniform maturity than a medium soil moisture.

A greater number of florets per head were produced when plants were grown in soils of medium and low moisture content than when they were grown in soils of high moisture content. No significant difference was observed in the number of florets per head on plants grown in soils of medium moisture and those grown in soils of low moisture content.

The differences in soil moisture did not appear to affect the physical condition of the pollen.

Atmospheric humidity did not affect the setting of red clover seed under greenhouse or field conditions. Pollen under conditions of high atmospheric humidity showed a greater tendency to cohere than under conditions of low humidity.

When the plants were growing under field conditions, cross-pollinated red clover florets wet with meteoric water produced seed.

In laboratory tests not all pollen grains burst immediately when placed in water.

464. The researches of the author, carried out with spring wheats, oats, barley, clover and beet on sandy, clayey and peaty soils have shown that: (1) the action of water as a factor of growth is not influenced by the nature of the soil, provided that this action is calculated solely with reference to the quantities of water which are available for the plant; (2) the different species of plants behave very differently. For a yield per hectare of 20 quintals of grain and 20 quintals of straw of oats, wheat and barley, of 70 quintals of clover and of 300 quintals of beet roots plus 300 quintals of tops, the water requirement in cu.m. per hectare is shown as follows:-

	Sand.	Clay.	Peat.
Barley	1,320	800	1,100
Oats	1,200	1,680	1,040
Summer Wheat	1,280	1,120	1,120
Clover	3,500	-	2,320
Red Beet	-	2,520	-

(3) the amount of evaporation is influenced by the nature of the soil on which the plant grows; (4) the maximum amount of water is utilised for high yields; (5) on the basis of these findings, it is possible to calculate the quantity of water necessary to the plants during their period of growth in order to obtain a good yield. The results of the experiments have shown a good agreement between the recorded and the calculated values.

465. To determine the relation between climatic factors and the infestation of winter rye by Euxoa segetum, Schiff., observations were carried out in various districts of the Government of North Dvina in 1922-27. Detailed climatographs showed that the chief factor is the quantity of rainfall in May and that rain in July occasionally plays an important part in checking an infestation.

About 40 mm. of rainfall or less formed the most favourable conditions for an outbreak; the activity of the moth decreased in direct proportion to the increase in rainfall from 40 mm. to 60 mm. and was reduced to a minimum by a further increase up to 80 mm. or more, so that finally it was hardly noticeable on sprouting winter rye. A decrease in rainfall from the optimum caused a similar reduction in activity, no infestation occurring when it was 15 mm. or less. This relation between rainfall and outbreaks may be explained by the fact that both the mature larvae in May and the young ones in July easily succumb to fungous and bacterial diseases after heavy or frequent rains. In 1926 the percentage of larvae killed was 25, and in 1927 over 37.

466. The Agricultural Chemist has continued his investigation of the leaching of fertilisers under local conditions. The following is a summary of results in respect of the amounts of drainage;

(1) The average drainage from the uncropped plots is greater than that from the cropped plots, being about 2/3 and 2/5 of the annual rainfall respectively.

(2) The amounts of drainage from the different plots vary, being lowest from the nitrate of soda plots and highest from both superphosphate plots and the muriate of potash uncropped plot.

(3) The amount of drainage is directly correlated with the rainfall and, under certain conditions, appears to be dependent on the intensity of the latter.

(4) There is no direct relation between drainage and soil temperature.

The results as regards the composition of the drainage waters, were as follows:-

(1) Calcium oxide (lime) and nitrates are present in largest amounts, chlorine to a lesser extent, and potash in much smaller proportions. No appreciable quantities of phosphoric acid or ammonia are present.

(2) The large amounts of lime and nitrate found in the drainage waters are due to the soil disturbance. The addition of nitrogenous fertilisers to the plots at the rate of 60 lb. of nitrogen per acre does not appear to have influenced either the total amounts of nitrate nitrogen or the concentrations of nitrate in the drainage waters.

(3) There are much smaller amounts of fertilising constituents in the drainage waters from the cropped than from the uncropped plots. Towards the latter half of the year, the amounts of fertilising constituents found in the drainage waters from the former were small.

(4) The amounts of soluble constituents in the drainage waters are almost directly proportional to the drainage and hence the rainfall.

(5) The smallest amounts of nitrate nitrogen in the drainage waters are found in the nitrate of soda plots and the largest in the cyanamide plots.

467. *Opinions have differed regarding the optimum degree of moisture associated with the presence of Collembola, and experiments were therefore carried out to ascertain the influence of variation in relative humidity on the death rate of certain species.

At a uniform temperature of 25°C. it was found that saturated conditions of environment are necessary for the survival of all the species tested. With the exception of the genus Entomobrya, Collembola devoid of a tracheal system proved very susceptible to dry conditions. Smynthurus viridis, L., which possesses a tracheal system and a well-developed ventral tube, is much less susceptible to atmospheric dryness, surviving much longer in the unsaturated atmospheres than the other species. An experiment with S.viridis suggests that the ventral tube is used for conveying droplets of water from the hairs of the body to the mouth and also serves as a cleaning organ. The susceptibility of Collembola to atmospheric moisture was found to have a direct practical application, for although trapping on a tarred surface afforded efficient control, it was found essential to apply the method in the early morning or after rain had fallen when they were present in large numbers, for when the surface became dry they moved down into the soil.

468.* 1. Plants were grown under 4 sets of light conditions: (1) under cloth shades inside a greenhouse; (2) under cloth shades out-of-doors; (3) in a constant-condition room supplied with artificial illumination; (4) in a series of houses covered with glasses transmitting light in definite spectral regions. Curves are presented showing the influence of the intensity of light upon the total production of dry matter, percentage of dry matter, height, growth, and ratio of roots to shoots. Studies of chlorophyll concentration, leaf area, and time of flowering and fruiting were also made. The effects of different qualities of light on growth are shown. A discussion of the silvical and ecological significance of the studies is given.

2. The light needed for the survival of the plants grown is very low, being less than 40 foot-candles for all except sunflower, which requires a much higher intensity.

3. Redwood and loblolly pine are able to survive for a period of 6 months under an intensity of light at which they are barely able to increase in dry weight. Sunflowers, on the other hand, died within 2 or 3 weeks.

4. At low intensities of light the dry weight produced by the plants studied is almost directly proportional to the intensity received up to about 20 per cent. of full summer sunlight. At higher intensities the slope of the curve falls off, shade plants showing a decrease at lower intensities than sun plants.

5. The percentage of dry matter in tops, the ratio of dry weight of roots to dry weight of shoots, the density of growth, the strength of stem, and the leaf thickness all increased with increasing intensity of light.

6. Leaf area and height attained maxima at intensities of light of about 20 per cent. of full summer sunlight.

7. Chlorophyll concentration increased with decreasing intensity of light until the intensity was so low that it hazarded survival. Further decrease in intensity of light caused a decrease in chlorophyll concentration.

8. The time of maximum flowering and fruiting was considerably delayed by low intensities of light. Fruiting did not occur at all in the plants studied in intensities below 8 per cent. of full summer sunlight.

9. The entire visible and ultra-violet solar spectrum is more efficient for the growth of the plants studied than any portion of it used; the blue region of the spectrum is more efficient than the red region.

10. The intensity of light is usually a limiting factor in the growth of the vegetation under a forest canopy.

11. The quality of light is not a seriously limiting factor in the growth of plants under forest canopies.

12. Moderate variations in soil moisture are not likely to cause significant changes in the dry weight produced by plants provided the moisture content is not so low that it approaches the wilting co-efficient, or so high that it approaches saturation.

469.* 1. A further number of species has been subjected to curtailed daily periods of light. It was found that Phacelia campanularia, Nigella damascena, and Nemophila insignis reacted as long-day plants. These species prolonged their vegetative growth when subjected to short days.

2. Flowering was delayed by short periods of light in the case of mangolds, whilst sugar beet ripened its fruit more slowly under a period of 10 hr. light per day. The varieties of swede tested did not show any striking difference between the 10-hour and control series.

3. It was found that the habit of growth of a number of species when grown under a daily period of 12 hr. daylight, prolonged by 5 hr. electric light of weak intensity (2-5 c.p.) resembled that of plants receiving the full natural daylight (some 16 hr. a day) far more closely than that of plants receiving 12 hr. daylight a day. This was observed with both short-day and long-day plants.

4. Other species tested indicated that light of weak intensity can modify the rate of tuber production, and the utilization of the food products.

5. The increase in dry weight of plants receiving short periods of illumination may, in certain species, be greater than that of plants receiving longer periods of light. It is the writer's opinion that the rate at which food products are

utilized

utilized either for growth or for storage purposes in tuber or seed, where a large quantity of carbohydrates is quickly packed away, is one factor tending to control the general synthesis and the production of dry weight.

470. An apparatus for trapping insects in vineyards is described that is constructed on similar lines to one already noticed but differs in minor details. The author considers that the insects are attracted to the trap by the ozone formed in the air by the action of the ultra-violet rays from the lamp and are subsequently benumbed by it.

471. *In considering the relations of climate to the distribution and abundance of economic insects, it is necessary to restrict the study tothose regions in which outbreaks may occur. The insect may be captured in other places, but such captures indicate the presence of physiographic or edaphic variations, and cannot be correlated with climatic conditions. Within the area of economic distribution of the species it is possible to recognise three gradations of abundance and destructiveness, which may be correlated with climatic conditions. This makes it possible to define three bioclimatic zones for the species. In certain regions the insect is well adapted to the normal climate, and would cause outbreaks every year, if it were not controlled by variations from the normal climate. Climatic extremes, which would wipe out the population, are either absent, or very rare and local. In this zone the insect is controlled largely by its insect parasites. The zone so defined may be called the zone of normal outbreak conditions. In regions adjacent to the normal zone the insect is not adapted to the normal climate, but to variations from the normal, and outbreaks follow these variations. Severe extremes, which almost wipe out the population, occur at frequent intervals, but a permanent population is maintained which can serve as a nucleus for an outbreak when conditions become favourable. In this zone parasites are of less importance, and outbreaks are frequently checked by fungous and bacterial diseases. This may be called a zone of occasional outbreaks. In regions still further removed from normal conditions for the insect, a permanent population is not maintained, but outbreaks caused by migrants may follow outbreaks in the inner zones. These outbreaks are controlled directly by climatic extremes, or indirectly by fungous and bacterial diseases. This outer zone may be termed a zone of possible outbreaks. In the outer zones, parasites may be of importance, but they must be forms having other hosts which are adapted to the climate of these regions. The specific parasites of the insect will rarely, or never, follow it to the extremes of distribution. These three zones are definitely correlated with climatic conditions, and, if the critical climatic conditions are known, it will be possible to set definite criteria for their limits,based upon the probability of occurrence of favourable or unfavourable conditions. This has been done for the pale western cutworm (Porosagrotis orthogonia, Morr.) in another study, part of which is presented in abstract.

472. The plants for the two series of experiments reported, employing a temperature of 26°C. for 1925 and 20°C. for 1926, were grown each under four conditions, (1) ordinary

greenhouse

greenhouse conditions during March, April and May, but with temperature and humidity controlled; (2) a similar greenhouse with 6 hours' additional illumination (12 midnight to 6 a.m., from a gantry crane carrying 48 1,000-watt gas filled lamps); (3) same illumination as in (2) except 6 p.m. to midnight, with additional carbon dioxide (as near 0.3 per cent as was found practicable); and (4) constant light room, artificial illumination only, 25 1,500-watt gas-filled lamps, and 4 mercury-vapour tubes, temperature and humidity controlled, and carbon dioxide concentration increased.

Grains, such as oats, spring wheat, and barley, grew and yielded well even at a relatively high temperature (26°C.) if given additional light and carbon dioxide. With additional light only, the plants grew lower and made fewer heads. Plants of (2) and (3) flowered and fruited much earlier than did the controls. With additional light and carbon dioxide, barley grows and yields well even at high temperature and with abundant nitrogen supply. Potato is definitely limited to a low temperature and does not utilize additional light and carbon dioxide at high temperatures.

As reported by Garner and Allard length of day was found to have a marked effect on the flowering and fruiting of several plants, regarding which particulars are given.

Sweet peas, petunia, and snapdragon flowered profusely on a 24-hour artificial day in the constant light room. In general, this flowering was not greatly affected by temperature changes between 20°C. and 26°C., but sweet peas grew and flowered most luxuriantly at the lower temperature.

Red clover was grown from seed to flower in 38 days in 2 green-houses and in the constant light room on 18-hour and 24-hour days, respectively. Additional concentrations of carbon dioxide increased both the height of the plants and the amount of flowering.

473. Numerous observations and experiments have demonstrated the effectiveness of cathodic rays in destroying injurious insects, and ultra-violet rays have been found to attract both diurnal and nocturnal species. The rays appear to produce in the insects a sensation that is at first agreeable, but which sone becomes dangerous, if not fatal; in certain cases they are immediately blinded. A trap apparatus for use in vineyards, orchards or fields is described, to which insects are attracted by means of ultra-violet rays, and are either drawn by the suction of an electric fan into a metal basket or fall blinded outside the trap, where they become an easy prey to birds.

474. With an equal distribution of rainfall over the 4 months of the vegetation period, a lower average temperature during the period May to August induces higher quality of fibre. The same correlation between quality of fibre and average temperature is observed in all flax growing districts of U.S.S.R., independently of distribution and amount of rainfall. An equal amount and distribution of rainfall are not of equal value in the presence of different average temperatures of the vegetation period. With a certain temperature, some

decrease

decrease in amount of rainfall may be observed without impairing quality of fibre. The correlation between average temperature and rainfall allows of dividing the flax-growing tracts of U.S.S.R. into 5 regions according to the different properties of the fibre. Within the limits of every region, rainfall and temperature influence the quality of the fibre approximately in the same degree.

475. The thermal relations of several Japanese strains of Helminthosporium turcicum, causing leaf blight, and of H.maydis causing a leaf spot of corn, were studied. Rice decoction agar proved to be particularly favourable for mycelial growth; and Hopkin's nutrient solution solidified with 2 per cent. agar for sporulation. The minimum temperature for the growth of H.turcicum was between 5°C. and 8°C., the maximum near 35°C., the optimum between 27°C. and 30°C. The minimum temperature for the growth of H. Maydis was about 10°C, the maximum 35°C, the optimum 30°C. Aerial mycelium developed best at 23°C. and 27°C. for both species. Conidial formation was best at 23°C. The maximum temperature for conidial formation with H. turcicum was 30°C., with H. maydis 33°C.; the minimum temperatures were 11°C. and 15°C. respectively Immature perithecia of H. maydis (Ophiobolus heterostrophus Drechsler) developed on Hopkin's agar between temperatures of 23°C. and 30°C., the best development being at 27°C. The shape of the conidia of H. turcicum did not vary greatly at the different temperatures. With H.maydis, the conidia developed at 15°C. were straight and cylindrical; those developed at 23°C. to 30°C. were curved, fusiform, or lunate; while at 33°C. they became very irregular in shape. The conidia of H. turcicum were largest at 15°C. and became gradually smaller up to 30°C. The conidia of H. maydis were very small at 15°C, and the contrast with those of H.turcicum produced at the same temperature was very great. The spores of H. maydis became larger with rise in temperature and were largest at 19°C., showing no great divergence in size up to 30°C. At 30°C. there was no great contrast between the 2 species in regard to conidial length and width. At 15°C the number of septa for the 2 species was almost identical, while at 30°C there was a decided difference. As a result of inoculations, the spot disease caused by H. maydis was most severe at 30°C. while the optimum temperature for the occurrence of the leaf blight caused by H. turcicum seemed somewhat lower. There was no great difference between the thermal death-points of the 2 fungi.

476. Movement of water by capillarity from moist to drier soil was extremely slow and slight in both amount and extent. Inability to maintain uniform moisture content in the soil is a serious source of error in many water-relation studies. With fruit trees in containers, at each application of water the soil mass was raised to its maximum field capacity throughout, and the trees were allowed to deplete the average soil moisture to different extents. Range of moisture fluctuations was slight in some cases, while in others it was as much as from the maximum field capacity to the calculated wilting co-efficient. There was no relation between soil moisture content and either use of water or growth in length. When soil moisture content was reduced to a percentage corresponding to the wilting co-efficient, the trees wilted and did not revive until water was again added to

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the soil. Prunus trees growing on soil with water content higher than that corresponding to the wilting co-efficient showed markedly wider stomatal openings by day than those grown on soil with water at or near the wilting co-efficient, but differences in width of stomatal openings of leaves could not be detected when the soil moisture contents varied but did not fall to the wilting co-efficient. Results indicate that the trees were not affected until the soil moisture was reduced to the wilting co-efficient.

477. Observations with soil points indicated that soil in spots where the sod cover had been removed had up to 24 times the water-supplying power of soil covered by sod, during periods of clear dry weather. The difference was greater the longer the interval between rains. Other factors affecting the growth of Picea glauca are discussed. Sod should be removed about the tree when reforesting old pasture land.

478. With a total daily illumination of 12 hr., progressive shortening of the alternations of light and darkness resulted in decided decreases in growth in soybeans, Rudbeckia bicolor L. and Cosmos sulphureus L. A minimum was reached with light-darkness alternations of about 1 min., while further shortening of the alternations to 15 sec. gave decided improvement in growth. The 1-minute periods induced chlorosis.

479. A colony of bees was exposed to ultra-violet rays for 5 min. to 20 min. at 1 m. to 80 m. and 22°C. to 37°C. The day following irradiation, the treated bees were noticeably more active and built more cells than the untreated colony. The larvae of the treated bees developed in 2 days less than the untreated; but at the longest exposure the young bees came out of the cells before they were fully mature, and perished.

480. Effect of climate on tree growth is briefly discussed in light of Russian and German yield tables for Scotch pine, European white birch and Norway spruce.

481. The influence of the medium upon mosses growing in it is very important. Sunlight is always more or less unfavourable to development of mosses, even the most heliophilous species. Mosses are also very sensitive to changes

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in temperature, which may rapidly become injurious if action is continued. Optimum temperature for development of these plants is relatively low, at least for the species of the temperate flora. In general, the higher the atmospheric humidity the more rapid the development and, conversely, continued desiccation stops growth in all species, even those most xerophilous. Modifications are especially marked when 2 or more factors operate simultaneously. Water is a medium very favourable to development of all mosses; even xerophilous mosses are able to accustom themselves to water. Action of the soil is even more important that that of water; for stems placed under ground take on appearance and structure of rhizomes with shorter, smaller, thinner walled cells; less cutinised surface; and leaves reduced to scales.Characters employed in classification are a product of definite factors of the environment and are repeated in successive generations because of the continuance of these influences. While it has not been shown that acquired characters can be inherited, they may be repeated whenever the causative influence is also repeated.

482. Each number contains a list of observation stations by name, year, latitude and longitude, and observers; a map of the stations; table of number of observations by months; data of leaf unfolding, first normal fruiting, and leaf coloration of a number of deciduous forest trees; of first flowers on several herbs, shrubs, and trees; of seed-planting, first appearance of fruit, and time of ripening for several grains; and a list of additional observations on numerous other plants for each year.

483. In this discussion it is concluded that parasites, predators and diseases on the one hand and limitation of the feeding space on the other are of little importance in maintaining the balance of nature. Temperature and air-moisture present an optimum combination that varies for the various stages of a given species. Any departure from this optimum shortens life, and this mortality that is due to climate suffices to explain the regulation of the number of the progeny. For instance, geographical range extends from the optimum combination to that with 100 per cent. mortality. The chief advantage enjoyed by social insects is their ability to rear their progeny under optimum conditions of warmth and moisture.

484. *The severe climatic conditions under which cotton is grown in the Gezira make it desirable to establish relations between meteorological data and irrigation practice.

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By means of a rapid and fairly accurate balance it is practicable to measure water loss when small boxes containing moist soil are exposed for short periods and under different conditions. The scope of this method has been ascertained by preliminary experiments as to (1) the dependence of water loss on moisture content of the soil, (2) the distribution of water loss through the day, (3) the comparison of water loss from sand and from Gezira soil, and (4) the comparison of water loss from shaded and unshaded soil. The application of data so obtained to field problems is facilitated by the fact that in respect to distribution and amount losses from soil are related to loss shown by a Piche evaporimeter. Within the canalised area alternation of irrigated and fallow land is responsible for local variations in atmospheric conditions. A daily fluctuation in the moisture content of surface soil from fallow land is recorded and may be instrumental in favourably modifying its physical properties. The heat of wetting of Gezira soil has been measured.

485. 1*. The limiting effect of rainfall on the ensuing cacao crop has been illustrated by reference to the Belgian Congo, San Thomé and Ceylon.

2. The absence of knowledge concerning effective rainfall and lesser limiting factors has been noted, and the necessity for narrower periods of harvesting has been pointed out.

3. For Amelonada cacao at Aburi and Asuansi no correlation exists between the total annual rainfall and the total annual number of pods harvested.

4. Evidence has been offered of a highly significant correlation existing at Aburi and Asuansi between the crop in any month with the rainfall 5 months and 6 months previously.

A thorough investigation of this relationship and the consequent definition of critical periods may conceivably be of more than mere commercial interest for prediction purposes. It is possible that the better knowledge thus acquired may be of direct agronomic significance both in its future possible application to irrigation, and in its more immediate assistance for the prescription of seasonal cultural methods.

486. A series of experiments was conducted to determine, firstly, the length of exposure necessary to kill the virus of tobacco mosaic, when purified and subjected to ultra-violet radiation from an unprotected quartz tube mercury-vapour arc radiator, in a water solution in thin layers between quartz and glass plates; and secondly, whether the virus could be killed by these rays within the plant tissue. The potency of the virus was tested by Holmes's method: the leaves of Nicotiana glutinosa are lightly rubbed with a piece of cheesecloth moistened with the virus solution, the potency of which is indicated by the number of colonies of dead cells

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or circular brown lesions developing on the leaves after two or three days' incubation. Irradiation was effected by distributing six drops of the purified virus over an area 2 in. to 3 in. square on a glass plate, covered with a quartz plate ½ in. thick, through which the virus was exposed at about 15 in. from the radiator. The quartz plate was then removed and 15 to 20 drops of distilled water added in order to saturate a small piece of cheese-cloth, with which the irradiated virus was lightly rubbed over the tobacco leaves. The first experiment showed that the virus could be completely inactivated by exposures of 1 min. whereas controls protected by window glass or a Noviol O filter (wave-lengths 312 μμ and 390 μμ respectively) produced large numbers of lesions after 10 min. exposure to mercury arc radiations. In subsequent tests it was found that most of the virus was inactivated after 5 sec. while not a single lesion was produced after exposures of 15 sec. 25 sec. and 45 sec.

Further experiments showed that the virus spread on the leaf surface could be killed by 1 min. immediate exposure to irradiation.

There was no appreciable loss of virulence, however, from irradiation the day after inoculation, the virus apparently resisting inactivation once it had penetrated a sufficient depth into the plant tissue.

487. The experiments described were carried out in an attempt to obtain a physiological explanation of the control of wing development in Aphids.

The percentage of winged individuals of Macrosiphum gei, Koch (solanifolii, Ashm.) produced by subjecting the wingless parents to alternate light and darkness was again found to depend on the length of the alternating periods and the ratio of one to the other; this was equally true whether the light was strong or weak, although the influence of less intense light was less marked. Little effect on wing production was produced by periods of less than 10 hr. of darkness or 2 hr. of light. The maximum wing production occurred with periods of 12 hr. to 14 hr. darkness alternating with 6 hr. to 8 hr. of light. The effects of single exposures to light or darkness were relatively small and very irregular.

Temperature did not affect the production of winged Aphids below 20°C. but wing production declined when the temperature was maintained above this figure, and ceased entirely at 26°C. and above.

Since almost all males are produced by wingless females and almost all gamic females by winged ones, the control of wing production in one generation controls sex in the following generation, in so far as gamic individuals are produced in the latter generation.

488. Ultra-violet light is destructive to the virus of foot-and-mouth disease. The rate of destruction, other things being constant, depends upon the concentration of

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the virus in the substrate. Lymph virus in a 1 in 50 dilution or dried was destroyed in 5 min. to 60 min. but concentrated guinea-pig lymph or epithelial shreds from guinea-pig lesions were still infective in most cases after an exposure of 60 min.

Exposure to sunlight during August proved fatal to the virus, but the shortest period of exposure which proved effective was 2½ hr.

The incandescent lamp (small sollux lamp) only killed the virus exceptionally in 1 hr. to 2 hours. Irradiation was apparently without effect upon the course of the disease in guinea-pigs.

489. Near Gifu, in the province of Mino, Honshu (Japan), downy mildew of cucumbers (Pseudoperonospora cubensis:) becomes prevalent at the end of June and generally declines to a marked extent from the middle of July onwards when the temperature reaches 30°C. The inception of the disease is greatly influenced both by rainfall and temperature the minimum temperature necessary for primary infection being about 10°C. to 15°C., and the optimum for development of the disease approximately 20°C. A moderate (but not excessive) rainfall also contributes to the occurrence of infection, which may fail to develop altogether in the complete absence of precipitation. Field observations from 1925 to 1928 indicated that the first symptoms of downy mildew usually appear about the end of May, but their development may be expedited or delayed by abnormally high or low temperature, respectively.

The optimum temperature for conidial production and germination was found to be from 15°C. to 19°C. The maximum temperature for production is 27°C. and for germination 30°C. to 32°C., and the corresponding minima are below 10°C. and 4°C., respectively.

490. Brief details are given of experiments which were carried out in Podolsk (West Russia) during the summer of 1925, in the course of the senior author's study of the biology of the Erysiphaceae, for the purpose of determining the influence of meteorological factors on the formation of the perithecia of the powdery mildews of Alchemilla vulgaris and Caragana arborescens (Sphaerotheca humuli and Erysiphe polygoni, respectively). The results indicated a close relationship between temperature and the production of these organs in both species, a fairly constant sum total of 310 to 320 centegrade degrees of daily mean temperatures from the moment of the first appearance of conidia being necessary to ensure their production. In the case of E. polygoni the period of time that elapsed between the appearance of the conidia and the formation of the perithecia was 5 days or 6 days longer towards the end of the summer than in mid-summer. Under natural conditions no regular correlation could be established between the relative humidity of the air and amount of precipitation, on the one hand, and the formation of perithecia, on the other.

491. This paper discusses briefly the various climatic factors that influence the occurrence of Arthropod vectors of disease. Their study is of particular interest to the epidemiologist, because insect-borne diseases already show to what a considerable degree epidemics depend ultimately on meteorological and other natural phenomena.

492. *The purpose of this experiment was to study the variations in temperature occurring within different regions of a hive during summer and to explain if possible to what the variations are due. The average daily temperature of the brood area is quite constant. The average daily external temperatures had very little if any effect on the average daily temperatures occurring in the brood area. The average daily temperature of the broodless area drifts proportionally with the rise or fall of the external temperature.

493. 1. *The productivity of alfalfa meadows occupying the land for the first time on the Nebraska Agricultural Experiment Station farm at Lincoln has declined rather abruptly about four to five years after sowing, even though a good healthy stand remains. This has been found to be due primarily to depletion of the available subsoil moisture. Such results are regarded as rather typical of most uplands in eastern Nebraska and similar territory where the annual precipitation is not supplemented by either surface or sub-irrigation. The natural restoration of the subsoil moisture supply is at so slow a rate, under usual cropping conditions, that far smaller yields may be expected from a second cropping to alfalfa than from the first.

2. The point of non-availability of moisture in these alfalfa meadows appears to be approximately 2 per cent. above the hygroscopic coefficient.

3. Alfalfa drew upon the subsoil moisture supply to a depth of 33 ft. in a 6-year old meadow and 25 ft. in a 2-year old meadow. At the end of 6-year, 3-year, and 2-year periods of growth in three upland meadows the free-water content had been reduced to approximately 2.5 per cent. to depths of 25 ft., 15 ft. and 7 ft., respectively. The average moisture content between the 5th and 15th foot in the 6-year, 3-year, and 2-year old meadows has been reduced 11.0 per cent., 10.6 per cent., and 9.4 per cent., respectively, below that in adjoining cultivated fields.

4. A 6-year old alfalfa meadow reached its peak of production in the third year, with 7.2 tons of cured forage per acre. Yields thereafter were curtailed by subsoil moisture depletion. The yields during the 5th and 6th years averaged only 2.0 tons per acre, even though a good healthy stand persisted. During the 2nd to 6th years the forage yield of this alfalfa meadow was about twice the total yield of adjacent corn and wheat fields, whereas in the 6th year its yield was only 79 per cent. and 67 per cent. as large, respectively, as that of these two cereal crops.

5. Irrigation of a portion of this meadow in its 6th year increased the yield nearly three-fold, bringing it up to 6.72 tons for the season compared with 2.35 tons without irrigation. This is evidence that the shortage of production was due to moisture deficiency.

6. Because of its excessive water requirement ratio, alfalfa cannot be expected to be as productive as the common cereal crops after subsoil moisture has been exhausted and it has become roduced to dependence upon the annual rainfall. Computations based on a water requirement ratio of 858 indicate that approximately 27 acre-inches of water were required annually to supply the transpiration needs of an alfalfa meadow during its 2nd to 6th years. This is

slightly

slightly in excess of the average annual precipitation during the period. During the 2nd to 4th years water requirement considerably exceeded precipitation. This extra requirement was met by the moisture of the subsoil which appears to have lost during the 6-year period a total of 32.9 in. To maintain the high yield attained in the 3rd year (12,206 pounds of moisture-free hay) would require 46 in. of transpirational water per year.

7. Under ordinary cropping conditions the natural restoration of subsoil moisture following alfalfa appears to be very slow. During 15 years of cropping to cereal crops following the breaking up of an established upland alfalfa meadow, very little moisture had accumulated beyond the 7th foot. The average increase in moisture content from the 5th to the 35th foot appears to have been 0.4 per cent. At this rate approximately 225 years would be required to restore the subsoil moisture removed by 6 years of cropping to alfalfa. Subsoil moisture was replenished more rapidly on low-lying land that received run-off from higher ground.

8. Alfalfa is greatly handicapped on land that has at some time previously grown this crop. In one series of tests a meadow sown 8 years after the previous alfalfa was broken up yielded as a 3-year average only 55 per cent. as much as a corresponding adjacent meadow that had not previously grown alfalfa. In a similar test started 4 years later the average yield for 2 years was only 35 per cent. as much. The average yield of the 5 crops of alfalfa grown in the absence of subsoil moisture was 1.78 tons per acre. Moisture tests showed that these results were due to deficiency of available subsoil moisture at time of planting.

9. Root studies in a 3-year old alfalfa field on land that had once before grown alfalfa showed undersized tap roots that branched profusely at a depth of about 5 ft. into a network of fine roots clinging to the faces of the many fissures which characterized the deep dry subsoil. These roots were traced to a depth of 14 ft. In a corresponding field that had not previously grown alfalfa the plants possessed characteristic long, sturdy tap roots, with many fine roots throughout the soil mass.

494. *In all studies on the water relations of plants in which soil moisture is involved, much greater care should be given to the manner of taking the samples and to the interpretation of the results. The use of the moisture equivalent for the reduction of moisture contents to a common basis is suggested. Variations in soil texture that are not interpreted by moisture equivalents or by any other of the so-called soil moisture constants may be great enough to make the results unreliable unless many samples are taken for each condition investigated.

The data in this paper indicate that moisture under rows of grain-sorghum plants is apparently extracted in successive zones and the extraction is progressive whenever no material additions of moisture occur during the growing season.

The percentages for relative wetness expressed as ratios of soil moisture contents to their respective moisture equivalents, may be used to indicate the development of roots, and the results of adequate moisture samples, taken at proper

times,

times, indicate with a fair degree of accuracy the presence or absence of roots of plants growing on the soil tested.

A correlation has been shown to exist under the conditions of this study between the amount of roots and the extent to which the soil has been dried by root activity. The writers reason that if the soil is wet at the beginning of the growing season to the full depth to which roots of plants would normally penetrate, subsequent additions of water by rain or irrigation, unless adverse conditions for growth are brought about thereby, can have but little influence on the extent of the root system developed.

495. The author's treatment of the subject is, for the greater part of the publication, a criticism of the latest pronouncements of the meteorological experts on the subject, and in the main he is not inclined to endorse their findings. His objections are that they are too generalised, and that they attempt to treat a greatly diversified subject in too summary a manner. His criticisms based on his own observations in the field, lead him to the conclusion that forests exert a far greater effect on rainfall than meteorologists are inclined to admit. It is, in fact, another case of the field worker contrasting his experience with the deductions of the expert working from statistics in the office. The instances Mr. Nicholson quotes from Uganda and Kenya lend support to the general conclusions at which he arrives, but which he states he only advances on behalf of East Africa.

Briefly these conclusions are, that changes in the covering of vegetation may enormously affect the total rainfall; that trees and deep-rooted shrubs contribute more moisture to the air than herbaceous vegetation or bare soil; that the mountain forests of East Africa can induce occult precipitation up to at least 25 per cent. of the total annual rainfall; that forests have little influence on cyclonic rain; that the local effect of forests on monsoon rainfall is up to 3 per cent. but the regional effect may be greater; that instability rain is greatly increased by the presence of forests.

The general and local effects of forests and stream-flow, and the value of windbreaks are discussed in the concluding chapters.

496. The past three years' tests have shown a marked relation between the environment during the period of maturation and the subsequent growth responses of the seedling as well as the complete seasonal development and yield of the crop. High yielding, resistant strains of spring wheat became susceptible and poor producers when the seed was grown one season under the hot, midsummer conditions of central Illinois, whereas the seed of the same strains matured at Madison, Wis., resulted in resistant plants and yields characteristic of the strains.

Similar results have been obtained in late-maturing inbred lines of corn when grown at Madison under unfavourable autumn conditions. This so-called immature corn even in highly resistant inbred lines has been completely susceptible to seedling blight and produces plants and ears of marked

inferior

inferior quality, unlike those from the original line or from plants from well matured ears of the same line. This does not seem to be a disturbance of the genetic composition of the line but rather the expression of the characters. There is little difference in endosperm composition, but marked changes in the embryo. This influence of the maturation environment is of special importance in comparing strains or varieties matured under different conditions.

497. 1. The main work of contemporary agricultural meteorology consists at the present almost exclusively in parallel observations on the growth of some crops and the influence on them of meteorological factors.

2. The object of these observations, started in Russia in 1906 and in America in 1915-16, is the fixation of the "critical periods" in the growth of plants, in which they are most sensitive to excess and deficiency of heat and humidity, and the "correlational interdependence" between the harvest and the combination of the heat and humidity in the several intervals of the vegetative period.

3. This interdependence is of a rather vague character. It varies with the different climatic conditions for one and the same crop and shows a tendency of adapting itself passively to the climate.

The method applied in these researches is a passive observing one.

4. The meteorological observations, based on the contemporary international agreements, have but a limited value in the comparison of climates on broad scales, and their importance for practical agronomy is very small.

5. As a counterpoise to the foregoing and in addition to it, an experimental method is proposed to be applied at special microclimatic stations, observatories, and biometeorological laboratories.

6. The data on microclimate, or rather on bioclimate, are to be gathered by means of observations made with special instruments more exact and more sensitive than the ordinary ones, in the lowest strata of the atmosphere, 0 metres to 15 metres, having as their object the fixation of the movement and the limits of fluctuations of those meteorological factors most important for the life of the plants, which can directly bring to light the characteristics of the local climate.

7. The actinometric sections of the observatories, possessing exact physical instruments, mainly photo-actinometric, are to start a detailed study of solar energy, direct and dispersed, in the spectrum as a whole and also in its different regions, taking into account the local conditions of the solar climate.

8. Hand in hand with this the laboratories (bio-meteorological sections of the observatories) are to conduct, systematically and in detail, isolated vegetation experiments, using natural and artificial sources of light and an assortment of photo filters, the influence of light, direct and dispersed in the spectrum as a whole, and also in its different regions, on the development and chemical reactions of plants.

9. As data on microclimate are gathered, the different elements should be in the limits fixed by experience for given regions, and introduced into the vegetation experiments as new variables, enabling thereby the calculation of the influence of divers factors of the bioclimate on the growth of different crops.

10. The totality of gathered facts will enable us to fix, with the aid of specialists - chemists, physiologists, botanists, plant breeders, etc. - the climatic "formulary" of the plant, depending on the natural conditions of the region, and thus to tie together the vegetable world with climatic conditions by a causal and uniform nexus.

11. The struggle against the natural forces of a meteorological character is mainly the business of technical and rationalized agriculture; and if it be sufficiently industrialized, the influence of these forces can be reduced to a minimum. At the same time we can raise the favourable conditions, leaning on a firm scientific basis. The main lines of the struggle are already marked out, and with intense research studies success is assured.

12. If realized, this should give a mighty impulse to the raising to a higher level the quantity of agricultural production, on a basis of broad industrialization and enlarged scale, with reconstruction on a strictly scientific basis.

498. In an experiment conducted in controlled temperature chambers it was found that a heavier crop was obtained from tomato plants grown at a mean night temperature of 62°F. to 63°F. than from plants grown at mean night temperatures of 70°F. 57°F. and 58°F. It is probable, however, that plants grown at a mean night temperature of 57°F. to 58°F. were stronger than the others and might be expected to resist disease to a greater extent. It is emphasised that these results may not hold good for every year. It has been shown that a definite relationship exists between the hours of bright sunshine and crop weight. It therefore seems probable that the temperature also may have a big effect, and it is suggested that with much sunlight, plants may be grown at higher temperatures than may be the case when there is but little sunlight.

The slight increase in crop obtained by heating the soil by means of buried electric resistance cables was not beyond the limits of experimental error and would not warrant the use of these heating cables on a commercial scale.

499. (1)* The severity of tomato mildew is closely related to the atmospheric temperature and humidity. The effect of environmental conditions does not end with primary infection, but the amount of mildew which develops is largely determined by the conditions operating during the early stages of the disease.

(2) The optimum temperature for the various stages of mildew is about 72°F. Under humid conditions severe primary infection occurs at 50°F. to 55°F., but the subsequent development of the disease is very slow below 60°F. The temperatures usually prevailing in tomato glasshouses are favourable to mildew.

(3)

(3) Humid conditions favour the fungus and also produce soft, turgid plants which are very susceptible to mildew. The control of mildew by means of cultural practices rests largely upon the avoidance of humid conditions.

(4) The danger limit of humidity varies with the temperature. Under optimum temperature conditions primary infection is severe at 80 per cent. humidity but is rare at 70 per cent. humidity. Primary infection and the subsequent development of the disease are considerably retarded at 80 per cent. humidity when the temperature is about 66°F. A lower humidity is required to control mildew than to prevent it.

(5) In summer the persistence of humid conditions for 4 hr. each night is liable to cause severe attacks of mildew. Drastic ventilation during the day does not remedy the harmful effect of humid conditions during the night.

(6) The humidity in commercial glasshouses is rarely low enough to check mildew. The seasonal and annual variations in the severity of the disease are related to the temperature.

500. In 2 series of observations on groups of 4 and 7 cows, the milk yield of cows moved to a cold stall (temperature below 0°C. most of the time) fell off in the winter more than that of similar cows kept in a stall about 8°C. warmer. The percentage fat content of the milk was higher as the stall temperature was lower, though the absolute yield of fat was lower, because at the low temperature nutrients must be used for heat production. Computations indicate that such a necessity is liable to arise when the stall temperature runs lower than -3°C. or -4°C.

501. *Development of ova of pig and human Ascaris was observed throughout 1926-27 in Southern Alabama. Soils apparently have little influence in the epidemiology of ascariasis. Ova in pig faeces developed more rapidly and at lower and higher temperatures than in human faeces. Drying was the greatest lethal factor, ova in direct sunlight in summer (98°F.) disintegrating in 3½ hr. to 15 hr.; under higher temperature in incubator, less rapidly; and sufficiently slowly in dry shade to permit development of some ova, depending on humidity. Trichuris ova disintegrated more rapidly than Ascaris. In shade, under natural conditions in summer, ova developed to the motile stage in 10 days to 15 days. Kept moist in direct sunlight the majority of ova of human type disintegrated without development in 30 days; the majority of pig ova contained embryos. In incubator (40°C. to 50°C.) human Ascaris ova, kept moist, failed to develop in 15 days, a large proportion disintegrating; ova of pig Ascaris developed slowly. Transferred to natural

conditions

conditions, ova of human type failed to develop in 15 additional days; 85 per cent. of pig Ascaris ova contained embryos. The moisture requirement of Ascaris ova, though definite, is low. Saturation greatly retarded development.

502. *Onion, beet, radish, pea, carrot, tomato, cucumber and lettuce were studied. Six kinds of alternations of temperature were used, as follows: 16 hr. at 4°C. + 8 hr. at 25°C.; 16 hr. at 8°C. + 8 hr. at 25°C.; 16 hr. at 11°C. + 8 hr. at 25°C.; 8 hr. at 4°C. + 16 hr. at 25°C.; 8 hr. at 8°C. + 16 hr. at 25°C.; and 8 hr. at 11°C. + 16 hr. at 25°C. All the work was carried on in soil. The alternation of temperature in these experiments did not increase the percentage of seedlings. The daily use of low temperature (4°C., 8°C., and 11°C.) during 16 hr. in connection with high temperature (25°C.) during 8 hr. gave better results than the reverse combination. The coefficients of velocity of germination vary according to the change of lower temperature. The rate of increase of the coefficients was dependent on the effect involved by temperature acting 16 hr. daily. The stimulation of the growth of seedlings, as a consequence of alternation of temperature, was found for most of the species studied.

503. Insect life depends mostly upon external forces, as climate, temperature, ecology, etc. A number of examples is given. Charts show the flight-years of the May-beetle (Melolontha sp.) and its distribution. The reasons for variation within a species, should be especially studied.

504. *On account of the uniformity and enormous extent of the belt of the Russian plain and the almost complete absence of mountains the climate is the chief factor in landscape formation. With the flat conditions of Russia this develops in zone form mainly in the direction of latitude and is subject to the influence of solar and Atlantic climatic factors.

The orderly series of latitudinal climatic zones is accompanied by a corresponding arrangement of territories in which soil and vegetation on the one hand and sanitary, economic, and social conditions on the other are the same.

Almost one quarter of European Russia is waste land, whose geographic features, nature of soil, and character of climate - marked lack of warmth in the north and lack of water in the south - are altogether incompatible with any form of culture; hence the presence of tundras in the north and the desert belt in the south are readily explained.

The climate of the flat part of Russia either shows the same characteristics detrimental to agriculture and necessitates recourse to primitive forms of farming in the

northern

northern Tayga (swampy forest) and in the southern steppes, or then it considerably hampers farming, as in almost all of the remaining parts of the middle forest and steppe regions, which comprise the greatest and best part of the arable surface of Russia.

The climatic extremes of the farming region are explained for the most part by extreme continentality and can be summarized as follows: (a) Marked change in temperature from summer to winter and from day to night; (b) in general, long-continued, severe winter, especially in eastern Siberia, and hot summer in the south; (c) scant amount of snow in Siberia and great extent of perpetually frozen ground; (d) lack of precipitation in southern and south-eastern Europe, the region of most fertile soil; (e) dissimilarity of rainfall régime in the whole farming area, and lack of rain in the spring and early summer (even in the region of the Atlantic wedge of maximum precipitation of eastern Europe), which injures forage plants, clover, and alfalfa, so necessary in crop rotation; (f) extraordinarily short growing season of 3 to 5 months; and (g) droughts, hot winds, dust clouds, heavy downpours and hail in the south and south-west, and severe night frost over extended areas.

The climatic extremes prevent the permanent colonization of ⅔ of the Russian region and impose upon the cultivated vegetation the stamp of a type of weather very fickle and productive of small yields. Hence expenditure on intensive agriculture does not pay and extensive forms of farming are not supported.

Although it permits farming in the forest belt and in the steppes, the climate of Russia is on the whole not favourable to agricultural development, especially in comparison with western Europe, India and China.

The climatic conditions make farming but little profitable in the greatest part of Russia; they hardly permit an extension of the farming area and make unattainable the raising of yields to the type found in western Europe, where the harvests are 2 to 3 times as great as those in Russia before the World War. Under present conditions on 96 per cent. of small rural farms it is not possible to count upon farming as the sole factor in the commercial, economic and social development of Russia.

For the further advance of Russia and for the easing of the struggle of man against natural conditions there must be a change to diversified farming of intensive type and a development of household industries.

Also, there must be development of mining in order that soil fertility may be renewed and introduction of labour-saving machinery, without which the betterment of the agricultural system is impossible.

505. * Pollen-tube growth was investigated in <u>Datura stramonium</u> by a special technique, using flowers of normal homozygous plants. Tests were made simultaneously in 8 constant temperature stations ranging from 11.1°C. to 37°C.

Observations

Observations at the end of 8-hour, 9-hour, 10-hour or 12-hour intervals were based on tabulated averages of 24 to 52 measurements per station. At 11.1°C. the average growth rate was 1.21 mm. per hr.; at 33.3°C. where the maximum growth rate was observed, the average rate was 5.53 mm. per hr.

506. Based on 1243 borings, the co-efficient of correlation between width of annual ring and June-July temperature in 1906-1922 was +0.62, or +0.81 if 1915 be excepted. Density of stand had little effect, but there was some difference on different soil types, the lowest correlation occurring in swamps. The good growth in spite of a cool summer in 1915 is attributed to accumulation of food material during the warm summer of 1914.

507. * A study has been made to determine the effect of temperature upon the growth of Fusarium oxysporum var. medicaginis in pure culture and upon its ability to attack the alfalfa plant.

The optimum temperature for mycelial growth of this fungus in pure culture is near 25°C., and the maximum is about 37°C. or 38°C. The minimum was not determined, but it lies somewhere below 3°C. In general it may be said that the cardinal temperatures for this fungus do not differ greatly from those for Fusarium oxysporum. Although F. oxysporum var. medicaginis is known to occur only in the South, there appears to be no reason, so far as its cardinal temperatures are concerned, why it should not be widely distributed throughout the country.

Experiments with Kansas Common alfalfa grown in soil at definite soil temperatures and moistures showed that 55 per cent. soil moisture was more favourable than 35 per cent. for its growth as well as for its infection with oxysporum var. medicaginis. Infection was more certain when the inoculum was inserted beneath the bark of the taproot than when it was added to the soil about the roots. The optimum temperature for infection lies near 25°C., and the disease develops, although poorly, at 35°C. The lowest temperature tried was 17°C., at which considerable infection resulted. Thus the optimum for infection agrees with that for mycelial growth. Infection takes place over so wide a range of temperature that this cannot be a factor in limiting the distribution of this fungus in the United States.

Grimm and Hairy Peruvian alfalfa are also susceptible to the wilt disease, showing about the same optimum temperature for infection. Grimm was slightly more heavily infected than Hairy Peruvian in these experiments.

Hairy Peruvian alfalfa showed a somewhat better growth at the extreme temperatures than did Grimm or Kansas Common.

508. For 2 years anti-mosquito measures were carried out within a 2-mile radius of the centre of the town of

Medemblik

Medemblik, which is situated on a promontory jutting out into the Zuyder Zee, but the density of Anopheles maculipennis, Mg., was not reduced to less than 1/3 of that outside the treated area, and the possibility of invasion from outside was considered, although it was not understood why the mosquitos should fly 2 miles in a northerly direction when food, shelter and breeding-places were immediately available to the south, east or west. Experiments with stained mosquitos indicated that the prevailing wind, which blows from the south, south-west and west, was a factor in their dispersion. It was concluded that in the absence of a wind sufficiently strong to carry them away, the mosquitos seek the nearest possible feeding places, otherwise they follow the direction of the prevailing wind. In this case it favours their dispersion in a northerly to north-westerly direction, and carries them much further than is necessary in the search for food, to the centre of the controlled area, where they are stopped by a dense human and animal population and a town-like arrangement of the buildings. In localities in this area the daily catches of A. maculipennis were almost 3 times as great on days following a wind that had passed over the untreated breeding-places as on days succeeding a sea wind.

509. * An account is given of the construction of tanks and chambers for the growing of plants under independently controlled soil and air conditions. The plants are grown in soil tins sunk in a water tank, the temperature of which is automatically controlled. Double-walled glass chambers fit over the tanks, and within these the conditions of temperature and humidity are independently controlled. Artificial illumination is provided by two floodlights over each chamber, with 500 watt gas-filled lamps in each, providing an illumination of the order of 1,000 ft-candles.

510. Observations made during this period have enabled a computation of the average time (and deviations from the average time) of flowering and maturity of 30 herbs and trees in northern Sweden. The report includes notes on arrival of migrating birds and seeding and harvest times in this section during the period.

511. * Many alfalfa plants of the Kansas common and Grimm varieties were frozen by different methods and for different lengths of time in order to learn something of the manner in which certain types of root injuries that are so common in the field are produced.

The results of these investigations have confirmed the belief of others as well as of the writer that the cracked and decaying conditions of the crown and of the upper part of the taproot of so many alfalfa plants is due to freezing.

The terms "phloem injury" and "heart rot" are used to designate the injury to those parts of the root lying outside of and inclosed by the cambium, respectively. Most of the plants frozen either died outright or recovered without showing any very striking external evidence of injury to the roots. A certain percentage of the plants, however,

did

did develop the lesions described in this paper as phloem injury and heart rot in one to several weeks after they were frozen.

Both phloem injury and heart rot developed in potted alfalfa plants frozen in soil at average temperatures of -6.6°C.,-8.2°C. and -11.6°C., for 5hr.,7hr. and 4 hr., respectively. Phloem injury alone was apparent macroscopically in plants frozen at -11.6°C.,-13.8°C.,-14.5°C., -17°C.,-21°C., and -21°C. for 3hr.,6hr.,7hr.,4hr.,2hr.,and 3hr., respectively. The plants frozen were grown in the field for about 8 months and then transferred to the greenhouse. As they were not frozen at once, they were not in a hardened condition.

Phloem injury developed in plants brought from the field and frozen at -14.6°C., and -14.9°C. for 1½hr. and 3hr. respectively, before being set in soil in the greenhouse. The same type of injury developed in 2 out of 5 plants of the same lot subjected to an average temperature of -14°C. for 7 hr. In this case the plants were set in soil in an 8-inch pot before they were exposed to the low temperature.

Phloem injury, heart rot, or both, became evident in 19 out of 275, or 6.9 per cent. of the young alfalfa plants frozen in soil at Madison Wis., in 40 days or less.

Phloem injury was produced in 3-months-old alfalfa plants by removing them from the soil and subjecting them to average temperatures of -14.2°C.,-12°C.,-12°C.,-12°C.,-6°C., and -11.5°C., for 15min.,15min.,20min.,25min.,40min., and 10min., respectively.

Attempts to produce the typical phloem injury or heart rot in plants in the field in the summer by covering them with a can containing ice and salt mixture were unsuccessful. The plants could be killed readily by this means, but they either died or recovered without developing the typical winter-injury lesions on the roots.

Histological studies of some of the frozen roots showed that a typical splitting apart of the cells, especially along the rays of the root, usually was present. This tearing apart and the death of the cells in localized areas due to freezing, followed by their complete collapse and decay, result in the formation of the lesions described as phloem injury and heart rot. The typical splitting in artificially as well as in naturally frozen plants is illustrated.

Micro-organisms are commonly associated with the typical winter-injury lesions under discussion. The parasitism of five species of Fusarium and three of bacteria isolated from typical phloem injury and heart rot was tested. In no case did they infect unfrozen plants. It seems clear that those associated micro-organisms are for the most part at least saprophytes or at best very weak parasites.

Histological studies of the roots of nearly 300 plants of 16 different varieties of regional strains of alfalfa have shown that the rays are more or less severely split during the winter. If the injury is not too extreme the cracks formed are practically all closed during the following growing season.

512. Branches (30 cm. long of Prunus aequinoctialis Miyos., P. campanulata Maxim., P. Mutabilis f. praecox (max.) Miyos., P. serrulata Lindl. and P. yedoensis matsum, their cut ends in water, were kept in an ice-box, the air temperature of one compartment being 5°C. to 7°C., of the other somewhat higher. In all cases, flowers survived longer than on control branches.

513. The influence of outer temperature on animals, particularly invertebrates, or those with variable inner body temperature is discussed. The organism requires a supply of known, constant temperature and the relation between outer temperature and duration of metamorphosis may be expressed by a constant (T.t = constant). This rule is useful in predicting emergence of a known pest. The work of Kleine with the beet fly and fruit fly is reviewed. Using 1st January as a starting point, time calculation is impracticable. The developmental zero point is discussed, as is the effective temperature; and an improved formula is defined, expressing the thermal constant. Examples are given from the work of Janisch and Blunck. Moisture is an important factor in development (also food, atmospheric pressure, etc.). The critical temperature point is discussed. These points may be expressed graphically on a curve (hyperbola or chain line), best expressed in the general form: $y = m/2(a^x + a^{-x})$. A practical application of the rule is shown.

514. Lepidoderma albohirtum, Waterh. (greyback cockchafer) is unable to withstand maximum shade temperatures of 95°F. to 98°F., when such conditions last for 36 hr. and are accompanied by a warm land breeze. After enduring the heat for a few hours, the beetles congregate on the shady side of their feeding trees, but eventually fall to the ground and die.

On one occasion when the temperature was about 38°F. reared adults of Ceromesia sphenophori, Villen., were found on their backs in the breeding cage, but when the air became warmer most of the flies recovered. The occurrence of this temperature in September is apparently very unusual. It is suggested that if these Tachinids became numbed in the field they would be exposed to predators, but it is probable that they seek shelter on the approach of exceptionally cold nights.

515. Segmentation of eggs of 3 species of ascarids showed that A. Megalocephala requires 1½ times to 3 times, A. suilla 7 times to 8 times, as long a period as T. limbata for development. T. limbata and A. megalocephala have the same temperature coefficient (3.12), same limit of high temperature (38°C. to 40°C.) and same limit of low temperature (6°C. to 7°C.), at which development takes place. The corresponding 3 constants for A. suilla are 3.23, 36°C. to 38°C., and 7°C. to 8°C.

516. * The critical point for black root rot of tobacco on the pH scale was affected somewhat by soil temperature. In the soil used there was no black root rot or only a trace at any temperature in soil with a pH value of 5.6 or lower. Marked injury began at pH 5.7 at 15°C., at pH 5.7 or 5.8 at 18°C., at pH 5.8 at 21°C. and 24°C., and at pH 5.8 or 5.9 at 27°C. There was little or no injury at 30°C., even in soil with pH values of 6.0 to 6.9.

* *

The germination of tobacco seeds was not affected by soil reaction within a range of soil pH values of 4.6 to 6.6. Soil temperatures between 15°C. and 30°C. had less effect on the percentage of seeds germinating than on the length of time required for germination.

* * *

In the growing seasons of 1927 and 1928, the first characterized by slightly subnormal air temperatures with approximately normal precipitation and the second by normal air temperatures with excessive precipitation, the mean hourly temperatures of the soil in a tobacco field at Amherst, Mass., were below 24°C., and therefore favourable to black root rot in this soil (pH value about 6.0), with the exception of a few days in 1927. Under these conditions of soil temperature and soil reaction black root rot was sufficiently severe to reduce the yield of tobacco 40 per cent. in 1927, as compared with the yield in the more acid soils of adjoining plots.

* * *

The response in the growth of tobacco to certain soil reactions was affected by the temperature of the soil, even though Thielavia basicola was first eradicated by soil sterilization. Applications of lime which benefited tobacco at higher soil temperatures (27°C. and 30°C.) resulted in a retardation in its growth at lower soil temperatures (below 24°C.) in both cases as compared with the growth of tobacco without lime at the same temperatures.

517. Beloturka durum wheat was grown in 3 series of pot experiments, the series being differently supplied with water during each of the 3 developmental periods; sowing to shooting, shooting to heading, and heading to ripe. The number of heads and spikelets was determined by water relations during the 1st period. Ear-length and number of kernels depended on water present during the 1st and 2nd phases. The number of fertile spikelets was influenced by moisture relations during all 3 periods, but particularly during the 2nd and 3rd. Spikelet density and grain to straw ratios were determined during the 2nd phase. Ear and grain weight per plant were determined largely in the 1st period, but were also influenced by conditions during the 2nd. Individual kernel weight was dependent on water supplies during the 2nd and 3rd phases.

518. * A significant increase in the weight of radish and carrot roots was obtained by using Vioray glass and Vita glass, but part of this increase was probably due to temperature differences in the frames. The total increase, about 33 per cent., was not phenomenal. With lettuce the plants grown under Vioray glass and Vita glass in summer were the same weight as those grown under ordinary glass when no temperature differences interfered with the results. The small tests with cucumbers did not reveal any advantage due to Vita glass or Vioray glass, under which the leaves were once scorched by the sun's rays in midsummer.

In none of the experiments with radish and lettuce were marked differences observed in the rate of germination under the three glasses when the temperature was equal in all the frames.

519. * This experiment was undertaken to compare the protective value against rickets in young chicks of direct sunlight, sunlight through certain glass substitutes and the rays from a quartz mercury-vapour lamp. Direct sunlight proved the most efficient means of controlling proper calcium deposition in the bones of young chicks since bone analyses, apparent condition and radiographs have shown excellent bone condition throughout. In weight gains the chicks under ultra-violet rays from a mercury-vapour lamp were slightly superior and these birds also ranked high in bone condition as evidenced by radiographs and analyses. It is necessary to take into consideration, however, that the cost of the lamp, its operation and the extra labour required must be charged against the latter method. Over large numbers of chicks it becomes more practical.

Vita glass and cel-o-glass in the order named were also quite efficient, but not so much so as direct sunlight. If for any reason, such as a very early hatch or inclement weather, it is impossible to allow sunlight into the pends the use of these substitutes might be indicated.

Common glass was of doubtful superiority to no sunlight whatever in this test and it was found impossible to raise chicks to six weeks of age without experiencing severe leg weakness under these two treatments.

520. The author states that 53 forecasting stations to warn vine growers against impending attacks of Peronospora (Plasmopara Viticola) have now been established in the province of Alessandria where their services are proving of great value. Each station consists of a rain-gauge and a shuttered screen containing a maximum and minimum thermometer and a hygrometer. The observers record the daily variations in the weather and draw up a monthly bulletin.

During 1929 the temperature did not reach the minimum necessary for infection until the end of May, by which time growers had been saved at least three applications of copper sulphate. Towards the end of July growers in the vicinity of a station had given only three or four treatments whereas others had made six or seven.

521. * Pineapple plants were grown in 3 different soils and at moisture concentrations of 5 per cent., 10 per cent., 15 per cent., 20 per cent., 25 per cent, and 30 per cent. above the hygroscopic moisture of each soil. The plants of the series with 5 per cent. moisture in the Robinson and Waianae soils did not grow. Some of the plants in the Helemano soil, however, made a very slight growth. The plants with 10 per cent. moisture made some growth, but not sufficiently or uniformly enough to be considered as normal. The plants with 15 per cent. moisture made a slightly better growth than the preceding; this amount of moisture represents the minimum for pineapples. Plants with 20 per cent., 25 per cent. and 30 per cent. of moisture made a very good growth, indicating that concentrations of 20 per cent. to 30 per cent. are ample for growth of pineapples in most soils.

522. A full account is given of the writer's investigations, extending over the period from December, 1927 to August, 1928, on the factors influencing the slime disease (Bacterium solanacearum) of tobacco, tomato and other crops in Sumatra.

Inoculation experiments (which are fully described) on tomato seedlings in pots showed that the disease is favoured by soil humidity, the organism developing much more vigorously in the vessels of plants growing in pots, the soil of which was kept damp, than in those kept dry. In the most heavily watered pots, which showed most disease, the roots were not rotted, so that root rot is not a necessary concomitant of slime disease. Bact. solanacearum made little growth on agar cultures maintained in a dry state by the repeated heating of the Petri dishes. It would seem to be possible that the water requirements of the organism are such that it cannot flourish in dry soils. It was shown by experiments on tobacco and tomato that the wilting of the leaves of diseased plants is due to a shortage in the water supply to them and not, as suggested by some investigators, to protoplasmic poisoning in the leaf cells, with the result that their osmotic pressure is decreased. The plant reacts to the products secreted by Bact. solanacearum by the formation of gum in the vessels, the walls of which also show a yellowish-brown discoloration. Possibly the 'physiological drought' in plants attacked by slime disease may be partially due to this action of the secreted substances on the vascular system. That the leaf cells are not permanently poisoned by the bacterial toxins was shown by the fact that diseased tobacco tops cut off and placed in liquid recovered turgescence.

The dry, brown spots occurring on one or both sides of the midrib, between the lateral veins, and scattered along the margins of affected leaves, are attributed to the action of external factors, viz., sun and wind, on foliage deprived of its natural trugidity by a deficiency of water. The condition was experimentally induced when the water supply was reduced in various ways, and also when cut leaves, allowed to become limp, were rapidly moved or shaken to produce bruises similar to those caused by the wind to flaccid leaves. In the same way, the oval spots along the midrib may be explained by the up and down movement of the longitudinal leaf halves in rough weather, causing friction and consequent injury of the tissues.

These observations are thought to afford some explanation of the facts that slime disease is favoured by a high ground water level, and that heavy losses in the tobacco crop are sustained during a severe drought.

523. (a) *The total rainfall during the whole of the vegetation period appears to effect the quality of oats belonging to the early group;

(b) The rainfall of June and July is of particular importance for the quality of this group;

(c) To be still more specific, the precipitation during the last part of June and the first part of July is the most important for the lessening of the percentage of husk of oats of the early group.

524. The experiences of the writer (1) confirm the intensity and importance of the phenomena of the condensation of atmospheric water vapour by the soil, at least in southern regions; (2) emphasises the distinction that it is necessary to establish between dew properly so called and the deposits due to adsorption; (3) show that in the South of France and during the warm season, the condensation of atmospheric water vapour on the surface of the soil should be a general and permanent phenomena, and that dew properly so called is an accidental phenomena, very rare and of very short duration.

525. The writer speaks principally of technical needs which, especially at the commencement, were to be overcome by artificial rain. Then he deals with personal experiences with watering, and particularly with the value of watering with liquid manure, town canal water and other dissolved manures. In conclusion, he points out that under present day circumstances, with wisely measured application, watering can do good.

526. Following recent studies in cold hardiness in insects the author discusses in this paper the factor of absolute humidity and its influence on cold hardiness in Popillia japonica, Newm. (Japanese beetle) and Hemerocampa leucostigma, Smith & Abbott (white marked tussock moth) under Philadelphia conditions.

The paper is summarised as follows: Cold hardiness in the eggs and larvae of H. leucostigma bears a linear relationship to absolute humidity. Eggs are slightly more cold hardy than the 1st instar larvae; the 1st instar larvae are more cold hardy than the 2nd, and the 2nd more than the 3rd. Cold hardy eggs tend to produce cold hardy larvae. Cold hardiness of the Japanese beetle in relation to absolute humidity, relative humidity and environmental temperature has been determined for all three instars of the larvae and the adults of P. japonica.

Nutrition influenced the cold hardiness of Japanese beetles kept at the same temperature and relative humidity. Starvation of 3rd instar larvae for two weeks increased their cold hardiness; starvation for one month decreased it.

527. *For 6 varieties of dahlia, heavy root storage was correlated with a short day, and a fibrous root system with a long day. Floworing was independent of storage root formation, although certain varieties (Jersey's Beauty and Mrs.I.de ver Warner)

flowered

flowered and formed storage roots concurrently on a short day. Certain varieties (Arthur and Summer Red) flowered independently of day-length, while others (Jersey's Beauty and Warner) flowered only on a short day. Cuttings taken during late September and October developed various types of storage organs along the stem without forming either typical storage roots or fibrous roots. Nitrates accumulated in the leaves and stems of short-day plants, but were absent or present in only small amounts in long-day plants. The pH of stems or leaves of long-day and short-day plants varied only slightly from 5.4.

528. * A number of plants grown in the full daylight of a greenhouse were exposed daily to radiations of an Ulviarc mercury-vapour lamp for intervals varying from 10 min. to 30 sec. Stunting and other formative effects were seen with exposures of 1 min. and upwards. Exposures of 30 sec. on seedlings of Trifolium 6 weeks' old have no stunting effect but a favourable after-effect. Exposures of 2 min. given to Voandzeia receiving natural illumination 5 hr. to 7 hr. daily have a more serious effect than when given to a plant having a 12-hour day.

529. Attempts are being made to extend plant protection measures in Germany, hitherto limited to combating existent or imminent outbreaks of pests, to general preventive work. This development must be preceded by an investigation of the environmental factors on which the occurrence of a pest depends. The first step requisite is the mapping out of areas in which injury is permanent or frequent. A system of symbols and shading indicating varying intensities of injury is described. The determination of the areas leads to conclusions as to the factors (such as temperature, moisture, soil, etc.) governing attack. Such information, embodying maps and charts, is given regarding Blitophaga sp. on beet, and Cicadula (Jassus) sexnotata, Fall., Chlorops taeniopus, Ng. (pumilionis, Bjerk.) and Hylemyia coarctata, Fall., on cereals.

The areas of infestation by Blitophaga coincide only partly with those of beet cultivation. Lasting infestation depends on soil, topography, and possibilities for hibernation, and the weather in March plays an important part and to some extent permits of the prediction of the injury in the following months. Cicadula sexnotata is found throughout Germany, outbreaks occurring in the eastern dry region. They depend solely on the direct action of climate, a sequence of dry, warm years being particularly dangerous. Chlorops taeniopus is distributed throughout Europe. In Germany the area of injury is that in which summer and winter wheat are grown, climate having apparently no direct influence, and the severity of outbreaks depending chiefly on the condition of the principal food-plant at the moment of the appearance of the fly in spring. The condition of the plants depends on the weather in the preceding autumn and in spring, on the variety, and on the cultural measures adopted. Nitrogenous manures in spring tend to cause the leafy parts to remain soft for too long a period, whereas phosphoric acid rapidly renders the tissues firm.

Hylemyia coarctata is found throughout Germany, but the area of outbreaks does not extend farther south than the zone in which day temperatures of 10°C. and over do not last longer than 5½ months. This seems to be due to the short

vegetation

vegetation periods, which allows oviposition to occur in the interval between harvest and sowing, this being the only time when fresh, loose, ploughed soil is available. Other factors do not appear to have any influence.

630. The recent invasion of Palestine by Schistocerca gregaria, Forsk. (desert locust) afforded an opportunity for the staff of the hebrew University, Jerusalem, to investigate some aspects of the locust problem, and the results of these investigations are presented in this paper.

The larvae and adults of all locusts are much more resistant to external factors than the eg s, and the greatest mortality must occur in the egg stage. Laboratory experiments showed that the vital optimum is at 30°C. and 100 per cent. relative atmospheric humidity. Temperatures remain favourable between 25.5°C. and 33°C. while the humidity must always by very high. The less mature eggs are more susceptible to deficient humidity. Below 18°C. no development takes place. To ensure the conditions favourable for the development of eggs in the field, the rainfall must be sufficiently abundant and coincide with the period of oviposition, the soil must be thoroughly soaked to the depth of 4 in. during at least the first half of the development period, and the temperature of the soil must reach a daily average of 25°C. to 34°C. Under such conditions the mortality of eggs is very low, and an outbreak can develop if two favourable years occur in succession.

The regularity of the periodicity of outbreaks is an illusion. In Palestine the years of outbreaks were 1865-66, 1878, 1890, 1892, 1899, 1902, 1908, 1915, 1928-29. There seems to be an 11-13 years' period, but this is probably connected with the corresponding climatic periods dependent on the fluctuations of the sun-spots.

The causes of the dying out of locusts in invaded countries are briefly discussed. The invading swarms, which usually arrive in Palestine in spring, are already sexually mature. They lay eggs, and hoppers hatching from them reach the adult stage, but locusts of the second generation have never been observed to propagate further, and either die out or disappear in the desert. The locusts that died in Palestine in October - December 1928 were still reddish-brown, i.e., apparently sexually immature. Their disappearance could scarcely have been due to cold, since frosts in the coastal zone begin very late in winter, and the locusts began to die out simultaneously in Tel-Aviv, Jerusalem and Jericho, in spite of the very different climates. Observations by the author have proved that at temperatures under 20°C. the locusts do not feed, and their oxygen consumption becomes very low. This must mean that even moderately low temperatures make them less resistant to unfavourable conditions. It would appear, therefore, that the minimum temperatures in the permanent breeding areas of S. gregaria must be above 20°C. during the coldest months of the year, for a combination of cold and wet weather is particularly unfavourable to the adults.

The body temperature of locusts is the same as that of the surrounding air if there is no direct sunshine. Under the influence of the direct rays of the sun, the body temperature increases rapidly to above 40°C. even if that of the air is below this figure. This temperature corresponds to the optimum activity. The regulation of body temperature is achieved by

changing

changing the position of the body; in the morning, when it is cool, hoppers place themselves at right angles to the rays of the sun, so that a greater absorbing surface is exposed, at mid-day they place their bodies parallel to the rays.

Numerous observations were made on the activity of hoppers under field and laboratory conditions, and it was found that their activity depends on the temperature of the air, and that mass movements can be explained by reflexes. Other chapters contain observations on the respiratory metabolism of locusts, and descriptions of stages and moults, and of oviposition.

531. It has been found that past maximum years for field voles (Microtus agrestic and M. hirtus) in Great Britain show a regular periodicity of approximately four years. There is evidence that disease is the controlling mechanism in some instances and that climatic factors are also involved. With regard to the latter the author says:-

"The climatic condition most liable to destroy voles is probably a period of hard frost without snow covering. The Winter of 1928-29 was exceptional in this respect over most of England, and it appears to have reduced voles to a very low ebb. It seems, therefore, highly improbable that any serious plagues will be experienced during 1930 in those areas which were exposed to the long spell of frost in January to March, 1929. On the other hand, parts of North Wales and the North of Scotland, where a snow covering protected the voles from severe frost, have shown a considerable increase in numbers during 1929. It is probable that the higher population of voles normally present in the northern areas is partly due to snow protection during winter. Unfortunately it is difficult to obtain records of the amount of snow lying on the ground at any time - which is the important factor from this point of view.

There is no evidence that heavy rainfall is in any way deterrent to the increase of voles, though presumably a severe drought would act as a check".

532. * The chief purpose of the present paper was to test the different methods of determining the resistance to frost of plants. The greatest attention was devoted to the method of direct freezing.

For this purpose a special refrigerating installation was fitted up in the Physiological Laboratory of the Institute of Applied Botany. Two well isolated chambers, each of a capacity of 1.5 cu.m. were cooled by means of a refrigerating machine of Brown, Bovori and Co. Any constant low temperature up to 25°C. could be obtained in these chambers. The constancy of temperature was maintained automatically by means of thermo-regulators. During the experiments the temperature was under careful control. The air temperature within the chambers was determined by means of an electric thermometer, while the temperature of the freezing soil and plants was determined by a thermo-electrical element. The duration of freezing in the frost chambers was twice 24 hr. During this period the soil had time to attain the temperature of the air. Thus, in these experiments the same low temperature acted on the aerial, as well as on the underground parts of the plants. Cooling and thawing were both gradual. The degree of resistance to frost was established by determining the amount of dead aerial parts, when several days or several weeks after the experiment had elapsed. For this purpose all dead parts were

carefully

carefully cut off and the amount of dry substance in the dead parts, as well as in the living ones was determined. Different winter crop plants grown in autumn in wooden boxes or in pots were used for the experiments. Each box was divided into compartments and in these compartments 4 varieties or 4 different crops of different hardiness were grown 50 plants per check. The hardening of the plants took place in October in the open air, when the temperature of the air had settled at about 0°C. Of the indirect methods for ascertaining the resistance to frost of plants those used were the determination of the percentage of dry matter in the expressed sap by means of a refractometer, and the determination of the freezing-point, by means of the microkryoscope of Burian-Drucker. These determinations were carried out simultaneously with the determination of resistance to frost by direct freezing. For obtaining the sap, a hand press was used by means of which the plants were first triturated, after which the sap was expressed under a slight definite pressure.

The greatest number of experiments was conducted with varieties of winter wheat of different hardiness, in the beginning of the tillering stage. 31 varieties of winter wheat were investigated, the hardiness of which had been determined under field conditions by the Section of Variety Testing of the Institute of Applied Botany. The eightfold freezing of the varieties at different temperatures has shown that in the majority of cases the determination of resistance to frost by the method of direct freezing correlates with the determination made under field conditions. Divergences in the estimation of varieties were observed only when the varieties were more or less of the same resistance to frost. These divergences are explained by the fact that by the field method it is not so much the resistance to frost, as the winter hardiness of the plants which is determined. The verification of the method of direct freezing has proved it to be suitable for establishing varietal differences in resistance to frost. Of the indirect methods, the refractometric one gives in many cases a correct estimation of the resistance shown by the variety. The authors think it possible to recommend the refractometric method, as a rapid and simple one, for preliminary selection with regard to resistance to frost. The determination of the freezing-point of the expressed sap afforded less correct indications than the determination of the dry substance in the sap by means of the refractometer method. The resistance to frost of winter crops depends to a very large extent on the degree of hardening. With hardening of the plants at a temperature about 0°C. winter wheat was able to stand - 10°C. without being injured, at - 12°C. it suffered and only the hardiest varieties were able to stand - 15°C. A temperature of - 20°C. stood by winter rye was not endured by any of the varieties of winter wheat.

The resistance to frost of 9 Afghan winter wheats of different altitudinal origin was determined by the method of direct freezing. The hardiness of these wheats increases regularly with the altitude.

With regard to winter rye, a very wide range of resistance to frost was established. Tulun winter wheat was able to endure a temperature of - 20°C. while the southern forms of rye, native of Asia Minor, Persia, Afghanistan, perished at 12°C. and - 13°C.

The resistance to frost of different other crop plants was equally investigated. The following temperatures at which freezing occurred were established: winter colza rape - 9°C. winter oats and winter peas - 10°C. winter barley - 12°C. winter vetch - 15°C. It proved that in winter peas, as well as in a series of other crops, the least resistant parts of the plant are the underground ones. In winter peas the roots perished at 10°C., the aerial parts at - 12°C.

The

The determination of resistance to frost of the seedlings of winter wheat has shown how difficult it is to determine the hardiness of the different varieties at this early age. The resistance to frost of the seedlings depended in a high degree on the temperature at which germination had taken place. The seedlings of spring wheat were considerably less hardy than those of winter wheat.

533. Three varieties of wheat were used in this study, which related to a period of 7 yr. The fluctuations in the yields were combined to give a single curve of variation of yield. The curve of rainfall giving the best agreement was obtained from the total of rain falling during the 20 days before and the 20 days after breaking into ear. Yields were greater than the average when the rainfall during this period was deficient. A distinct correlation was shown to exist between mean winter temperature (December to March inclusive) and yields. High yield appeared to correspond closely with low temperature during these months; the period when brairding and tillering occurred. The number of hours of sunshine during these months appeared to have a compensatory effect with respect to temperature.

It is emphasised that these conclusions are applicable only to the district of Brittany.

534. 1. *It is possible to conduct comparative experiments regarding the influence of soil drought on the plant in open porous pots (earthenware or porcelain).

2. The degree of resistance to soil drought, shown by the cultivated plants, may be in some cases characterized by the dimensions of the injuries received by them in the comparative experiments during the period of drought.

3. The different plant organs show a different resistance to drought.

4. The plants in the state of wilting dry rather slowly. The process of desiccation of the plant is very complex. In many plants the water deficit is distributed rather irregularly over the plant. Some plant organs are able to maintain their life at the expense of other organs.

5. The study of the water deficit on different stages of wilting enables us in many cases to determine the lethal water deficit in different plants, and admits of inquiring more closely into the nature of resistance to drought.

6. The resistance of the different plants to the desiccation of their organs is very different. Millet may serve as an instance of a plant able to support a very strong desiccation of its tissues, while beans are plants of an opposite type.

7. With a considerable water deficit the plants sharply decrease the accumulation of dry substance and then entirely stop it. No perceptible decrease of dry substance has been observed during wilting.

8. The plants show a different ability of recovering

from

from the harmful consequences of drought during the subsequent favourable period. With congenial conditions during the period following drought, millet is able to yield an ultimate crop little differing from that of the controls, even after long and intensive wilting. Oats show under the same conditions after drought a decrease of dry substance instead of its accumulation.

9. The influence of mineral fertilizers on the resistance of plants to desiccation has not proved essential.

10. The shade plants of oats have proved more resistant to soil drought than the light plants.

535. *In the centre of the district considered there is a pronounced dry zone, the yearly rainfall of which is below 425 mm. Crops have the following requirements: (a) Wheat. Wheat requires low temperatures in October and November and high ones in January and February. In April and May high rainfall is necessary for a good yield. High January to February temperatures and high April to May (especially May), rainfall increase the yields and have critical importance. (b) Rye. Rye is less dependent on weather factors; it loves high humidity at the time of shooting in May and also partly in June, but this must not exceed 1½ times normal. (c) Spring Barley. Spring barley requires high rainfall in April to June. Rainfall is the decisive factor for the yield, so long as its quantity in April to June is not over 180 mm. In certain circumstances the favourable effect of long sunshine duration in March to April and short in May can be increased by the factor of rain. (d) Oats. Oats next to sugar beet have the highest water requirements. Times of seeding and shooting (April to June or May to June) are indisputably critical for yield. Next to rainfall long sunshine duration in March to April decides the yield. Low warmth in June suits the crop. (e) Peas. The conditions with peas were uncertain. This crop seems to be grateful for high rainfall in May, low temperature in June and partly also for low humidity in winter and high warmth in March to April. (f) Sugar Beet. For sugar beet yields high June to September rainfall is decisive. High warmth in June is favourable. For the production of sugar content, a rainy August is sufficient but during June and September only little humidity is needed. A long duration of sunshine in September and October increases the quality of the crop.

Only wheat is susceptible to temperature; for all other crops rainfall at certain times is decisive for a good yield. Long sunshine duration in March to April and short in May to June is in general good for corn crops.

536. *Good winter and early spring subsoil moisture indicates a good cotton season, but unfavourable conditions during the growing season, such as violent monthly rainfall change from wet to dry, continuous heavy to excessive rains, with resulting poor cultivation and heavy weevil infestation, may easily offset the early advantage. A cold winter tends to destroy the hibernating insects and cut down the spring emergence; this favourable cotton factor, however may be offset by late planting and a moist cool growing season, favouring the rapid multiplication of pests at a time when they will do the greatest harm to the delayed crop. On the contrary the disadvantages of a dry, abnormally warm winter or a late cold or extremely wet spring may be largely

compensated

compensated for by later exceptionally favourable weather conditions.

Other things being equal, the ideal year for cotton would be one in which there was good soil-moisture storage during the preceding winter, which should be sufficiently cold to destroy the hibernating pests; followed by an early spring of moderate rainfall, promoting planting and cultivation of crop; a moderately dry, hot summer, with abundant sunshine, but not really droughty and not subject to sharp reversals in rainfall or temperature, thus favouring care and growth of crop and holding down weevil (this condition would favour certain other insects, however, of less serious nature). Finally, a fairly dry, bright autumn and late frost, to remove all of the cotton from the fields without deterioration or loss.

537. Plot tests at the Oklahoma Experiment Station with 20 sorts of vetches and peas showed that only two species of vetch, hairy (Vicia villosa) and woolly podded (V. dasycarpa), and one variety of peas, the Austrian field pea (Pisum sativum), survived winter conditions without showing perceptible winter-killing. Hungarian vetch (V. pannonica) possessed a fair degree of winter hardiness, killing 4 per cent. in the mild winter of 1926-27 and 14 per cent. in the rather severe winter of 1927-28. The hay yields of the crops were in direct relationship to their winter survival.

538. The author gives a description of the methods and equipment used in experiments conducted.

In a series of abrupt exposures, where the temperatures were dropped suddenly, there was a well marked correlation between length of exposure and percentage of mortality, and this was true for every temperature used. Both species are unable to endure dormancy, S.oryza becoming dormant at approximately 7.2°C. and S.granarius at 1.6°C.; and in this condition they will perish in 17 days and 38 days respectively. During exposure to low temperatures, a continuous loss of weight occurs with each species, and this loss is regular and constant. The gradual approach of cold weather which "hardens" hibernating insects and enables them to survive the very low temperatures of winter, has the opposite effect upon grain weevils (and probably the whole group of non-hibernating insects) and causes death to occur more rapidly.

539. *Summarizing the results of the review of the question concerning the internal factors of the resistance of plants to frost and drought we must first of all acknowledge that we are far from its solution. Up to the present time we do not know exactly why, in some cases, withdrawal of water in consequence of freezing or drying leads to an irreversible coagulation of the protoplasm and the cells of the plant are killed and why, in other cases, such a coagulation does not take place and the plant recovers. The difficulties of directly influencing the constituents of the cell in a desirable direction, the absence of sufficiently elaborated methods for experimentally changing the state and composition of the colloids of the plasma as well as for introducing different substances into cell sap - all this obliged us to have

recourse

recourse to indirect methods in the study of the problem. The two principal indirect methods applied are the following: the study of the process taking place during the hardening of the plant to frost and drought and the comparison of the chemical composition and physical properties of plants genetically allied as closely as possible but differing sharply in their degree of resistance to frost and drought.

Up to the present time more definite results have been obtained in the study of resistance to frost. Both methods of investigation mentioned above have given conformable results, namely that a greater endurance is obtained by means of the accumulation of sugars and other soluble carbohydrates in the cell and by means of an increase of the water-retaining power of the cells in consequence of the accumulation of hydrophilic colloids. Which of these factors has a greater significance, we can not yet affirm at present.

The study of the problem of resistance to drought is in a less satisfactory state. The reason lies in the greater complexity of the conception of drought as well as in the greater diversity of methods by means of which the plants avoid a too intensive loss of water. If, however, we overlook the external means of protection of plants from desiccation and assume the fundamental statement that resistance to drought is the capacity of enduring permanent wilting, then we will be able to establish a pretty close analogy between the capacity of plants to resist frost and drought, i.e., we may observe the protective influence of the accumulation of water-soluble substances in the cell sap; a greater accumulation of hydrophilic colloids may also be shown in plants resistant to drought.

The analogy between resistance to frost and drought must, however, not be understood as an absolute identity of these peculiarities in the plant. There is a series of plants resistant to drought but not resistant to frost and vice versa the capacity of enduring freezing is far from always being accompanied by the capacity of enduring desiccation. Only deeper study of the chemical and physical peculiarities of the protoplasm and of other parts of the cell in resistant and hardened plants and a more detailed analysis of the process taking place during freezing or desiccation, may lead to a closer understanding of the nature of these phenomena and of the means which the plant possesses for resisting their harmful influence.

540. Resistance to frost is in strict relation to the nutritive conditions of the plant. The provision of potash and of phosphate plays the principal role. A favourable role, from this point of view, is often attributed to potash. The author has been able to verify this opinion in experiments on winter cereals last winter in a clay and sand soil. On the 16th October, 1927, a field was divided into two parts of which one received no potash manure whilst the other received KCl.40 per cent at 100 Kg. per hectare. On the 20th October Rye was sown. By the spring, the part with potash was good, whilst in the other nearly all the sowing had been destroyed. At harvest, on 5th July, 1928, the portion with potash was heavily infested with weeds. The yield was 11¾ qx. per hectare whilst the potash had enabled a yield to be obtained of 33 qx. It is conceivable that a plant properly nourished better resists adverse conditions, but the protective role noted in potash must lie in some

other

other factor than its nutritive value. Winter cereals stand up well to low temperatures, but they do not tolerate so well changes of temperature, the alternations of frost during the night and sunshine during the day in February and March which heave the soil and tear the roots. If the soil has received a heavy dressing of potash, it is firmer and damper in the top layer, it swells less under the influence of heat and freezes less easily. It is advisable then to give potash to winter cereals during the Autumn, or, if this is impracticable, very early in Spring. In Spring, as soon as the soil is dry, the cereals which have passed the Winter badly should be rolled. A rapidly acting nitrogenous fertiliser, i.e. containing nitric nitrogen, should be applied. It is very rare to see young winter cereals actually frozen. Dr. Baumann attributes the action of potash to the fact that K_2O. encourages the circulation of sugar and starch in the plant. Plants poor in potash develop less warmth and are more sensitive to frost than others. The fact has been shown at many research stations as well as in the pot cultures by Bolhuis at Wageningen. Liebig has already shown that potash gives the sap a greater concentration and a larger content of sugar. According to Prof. Roemer, resistance to frost is related to the concentration of the sap. The author has noted the protective value of potash in his own experiments on potatoes, legumes and buckwheat.

541. The strong resistance of potatoes to night frost when they have received a dressing of potash must be attributed to the conservation of water and to a slower cooling. The author has carried out experiments on the variety Eigenheimer in pots with soil poor in potash. The temperature could be varied at will. By comparing the concentration of the cellular juice, the potash content of the juice and the lowering of the freezing-point, the relation between the action of cold and potash manure was confirmed. A dressing of potash allows potatoes to resist night-frosts. This should be taken into consideration in the case of soils judged unsuitable for potato cultivation.

542. *The question has been studied as to the amount of soil moisture necessary to maintain the life of barley plants.

Experiments were made in a laboratory at a temperature of 20°C. and a relative humidity of about 60 per cent., samples from different soil profiles being used. Ten days old barley was watered once only and at the moment when the plants were dying the soil moisture was quickly and carefully determined. The hygroscopicity was determined by the Rodewald-Mitscherlich method.

A theory is outlined on the effect of soil colloids upon the availability of the soil moisture to the plant organisms.

543. (1) *The most favourable height of the water-table for the hay-yield varies with the variety of soil, and will be influenced by the level of the natural rainfall. Generally speaking it can be said that the heavier the soil and the higher the rainfall the more favourably a lower water-table will affect

the

the plant growth, whilst a high water-table is superior on lighter soils especially in dry years.

(2) The albumen content of the fodder is generally higher at the 2nd cut than at the 1st and at the 3rd than at the 2nd. The increase of the albumen content from cut to cut depends in the first place both on the increase of the proportion of leaf and the decrease in the proportion of stem. Further, generally speaking, the drier the growth period and the lower the water-table the richer the hay in albumen. Hay grown during a dry period is so considerably higher in albumen content that the deficiency in bulk resulting from the drier weather is more than compensated by the albumen increase.

(3) Root growth is greatly influenced by the height of the water-table. With a high water-table, grasses are only shallow rooting. In soil well drained and well aerated grass roots are encouraged to penetrate deeper. Stocks with deeply penetrating root systems are less subject to drought following a low rainfall than shallow rooted stocks on a high water-table: they are consequently more certain in yield.

(4) The variation in the composition of the plant stocks depends in the first place on the type of soil and the height of the water-table, and in the second place on the normal progress of development of the various types. An increase or decrease of the different grass varieties on moist or dry, light or heavy, soils is always determined by the demands of the locality. The final condition of the stocks is the result of the struggle to exist.

(5) With artificial watering, the lowering of the water-table at the period of cessation of growth is a necessary condition for maximum yield. Other conditions being similar, if the level of soil water does not fall in winter, then a drop in yield takes place. The favourable effect of these measures lies in the better aeration of the soil and more rapid warming on the setting in of growth in the Spring.

544. Comparison was made of the growth of plants in water in light and in darkness and in solutions alternatively deficient in or supplied with the principal nutritive elements. A food supply deficient in phosphates has no depressing effect on the production of dry matter by plants. Nutrition is increased within a small, but definite limit by light. The effect of differential feeding with K. was not very marked and light has practically no influence on the assimilation of that element. During the course of feeding with Ca. growth is practically arrested. The assimilation of inorganic radicals was affected by light as follows: bivalent kathions Ca. and Mg. more than K; anions O:NO_3 and SO_4 then PO_4. The nutritive elements of plants can be classified in relation to their response to light in the following order: CA, MG, S, P, NO_3, K. Light increases the absorption of H_2O but it has not been demonstrated that it influences to any extent the processes of transpiration nor the absorption of inorganic matter.

545. Definite stimulation of spore production occurs in cultures of Macrosporium tomato and Fusarium cepae exposed to ultra-violet radiation by a quartz mercury arc. The increased sporulation seems to be a result of stimulation rather than an indirect outcome of inhibitory action. The effects are

most

most marked with filters having a lower limit of transmission between 2,535 AU. and 2,800 AU. Lethal effects accompany exposure to shorter wave-lengths. Slight stimulation occurs when filters transmitting no lower than 3,120 AU. units are used, but none with those transmitting only to 3,334 AU. units. Irradiations of 15 min. to 30 min. produce a great increase of sporulation, as also does lengthy exposure to intense direct sunlight through filters transmitting no lower than 3,120 AU. units. The experiments with the mercury arc, however, tend to show that the disparity between the amount of sporulation under Vitaglass (Transmitting to 2,650 AU. units) and under filters transmitting as low as 3,020 AU. to 3,120 AU. units is due not only to a variation in intensity in this region but to a difference in the total energy transmitted.

546. Soils lightly cultivated without sub-soiling have the greatest water content because the drainage waters pass away more slowly and evaporation is less. Rolled soils are often warmer than hoed soils. In rainy periods, the warming of deeply cultivated soils depends on their water-holding capacity and on their heat conductivity. When it is a matter of light soils, it is necessary to aim at augmenting their absorbing power and their capillarity when deciding upon methods of cultivation. In summer, it is necessary to see that their power of storing water is maintained by cultural methods.

547. The author has divided Silesia into a certain number of climatic areas and has sought to determine for each of these the relations existing between the vegetation and the climate. In obtaining the divisions, in the first place, the relations with temperature have served as a basis for demarcation. Then those which have a special importance for plants such as distribution of rains, wind atmospheric pressure, solar radiation, etc. As these elements are related to sea level the climatic areas are classified according to altitude. Of all the cultivated plants, rye occupies the largest area. It is found above 1,000 metres. In the continental portion of Silesia it gives place to wheat, which leads one to suppose that rye is markedly effected by high temperatures. In the higher altitudes spring wheat diminishes in relation to rye. Spring wheat has its place only in the best regions of plain and hill, by reason of the short duration of its cultivation period and of the snowy winter. However, even in the good plain areas yields are not reached like those obtained in Saxony. Spring barley is of great importance. It supplants winter wheat inasmuch as its vegetative period is shorter. By reason of its small demand for soil cultivation and its use as forage, oats is more widespread than barley. However, its distribution is determined by climate. Its cultivation increases with altitude and becomes even more intense where wheat no longer thrives. If the cultivation of rye and of oats are compared, it is shown that the poorer the soil, and the greater the drought the longer is the vegetative period and the more rye takes the place of oats. In other cases, the cultivation of oats increases with rainfall and has a more favourable distribution in relation to rye and gains also on light soils. The cultivation of vegetables in Silesia is trifling in the regions of continental climate. The potato finds the best climatic conditions. Certain areas are suitable for seed potatoes. Research on beet has shown that it reacts strongly to a diminution of the vegetative period. The altitude which best

suits

suits its cultivation is from 300 metres to 350 metres. As for the cultivation of clover, it is very scattered in comparison with grass by reason of the high maximum temperatures accompanied by high atmospheric humidity and by very light winds.

548. Statistics of the 60 yr. from 1851 to 1910 are used in this enquiry. Beside the well known dryness of the month of September there appears to be a dry spell in April and May which is no more desirable for agriculture. The figures show that rain should be discounted particularly at the beginning of March, at the middle of June and between 7th July and 1st August. It rarely rains at the end of September and in the first third of June. Taking periods of five days, on the strength of these data over a large number of years, the beginning of a wet or dry period can be forecast with some certainty. After passing from the wet period from the middle of June to the 10th July to the consecutive dry period, there are five wet days from the 30th July to the 3rd August. It is found that 38 times out of 60, it rains on the 2nd August. In the 43 five-day periods there are on the average only 5 with 3 days of rain and only 9 with only 2 days of rain. The mean rainfall is 1.7 mm. From the 2nd March to the 10th May this figure is reached only three times but it is never exceeded. This confirms the tendency of the beginning of the year to be dry. In the month of August there are most frequently small rains and short periods of dryness in consequence (from 1 to 5 days) but not upwards of 6 days and more. On the average, each year the month of August has 2 or 3 wet or dry periods lasting from 2 days to 5 days whilst, on the other hand, in September there are outstanding dry periods of very long duration. In May, there are often many short rainy periods and more often long periods without precipitation. There are but few periods during the time considered when it is more likely to be dry than in the first half of April. There are some very long wet periods, particularly from the 1st March to the 20th March, from the 20th June to the 15th July and from the 10th August to the 20th August. These wet periods appear chiefly when centres of low pressure pass to the north of Berlin. When the thermometer falls, the frequency of the dry periods grows, when it rises this frequency diminishes. These conclusions are drawn from 14 tables. Examination of the period 1911-1928 has not appreciably led to changes in the averages.

549. As only the yield figures of the Hohenheim experimental field were used for comparison with the weather data, the results have only local importance. The correctness of the results was confirmed by other investigations. As an example of the results obtained, the findings for spring barley may be given. As regards the winter humidity from November to March it is stated "Precipitation above 100 mm. in the period November to December has as a rule a bad effect on yield. This is explained by the relatively small water requirement of barley. As for wheat, so also for barley, an early warming up of the soil is of great value. With an average temperature in the period January to February of 3°C. to 6°C., good harvests were obtained. All temperatures under 3°C. led to small yields. In March small rainfall was advantageous. In all years of over-average harvests the rain in March was about 120 mm. The optimum quantity of rain in April

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(seeding and shooting time) is 60 mm. to 80 mm. Quantities of rain outside these limits gave bad harvests. The investigations did not permit of any conclusions on the effect of April temperature and sunshine on the yield. In July (the chief ripening time), the quantity of rainfall should not exceed 80 mm.; the optimum lies between 10 mm. to 70 mm. The average temperature should be as high as possible; in the worst year this was in July 17.1°C. in the best year 20.1°C. The duration of sunshine, providing the foregoing conditions are fulfilled, cannot be sufficiently long".

550. Records of relative humidity and forest fires taken at fire towers of the Pennsylvania Forest Service show that "during periods of relative humidity above 50 per cent. fires do not flare up into uncontrollable conflagrations. When the humidity drops below 40 per cent. the situation becomes dangerous, and when 30 per cent. or 20 per cent. is reached an extreme fire hazard exists."

551. During the period from the autumn of 1928 to the spring of 1930, the climatic conditions in the eastern, south-eastern and east midland districts of England were very abnormal. Little rain fell in the winter, spring and summer of 1929, and this period of drought was followed by abnormal rainfall in the late autumn and early winter of that year. As a result of the 1928-29 drought, meadows and pastures carried little grass, especially on the lighter soils. In consequence, in many dairy herds the fat percentage rose. The most remarkable effect, however, was the depression in the percentage of solids not fat which in some herds frequently fall below the presumptive limit of 8.5 per cent.

552. This article calls attention especially to the influence of plant cover on the temperature of the air at different heights above the soil up to 2 m. It is shown that the temperature near the soil is sufficiently modified under certain conditions to be of considerable importance in relation to plant growth. The effect of closely clipped sod in lowering the night temperature at 5 cm. above the soil was found to be especially pronounced.

553. Marquis wheat frosted at different stages of maturity in several seasons was subjected to quality, germination, milling, and baking tests.

The severity of the damage appeared to depend upon the moisture content of the wheat kernels at the time of frost and the temperature and duration of such frost, a temperature of from 29°F. to 27°F. being low enough to cause frost damage in immature wheat. While degree of maturity had little relationship to germination in normal wheat, germination decreased as the kernels were the more immature at time of freezing. Frosted wheat had a lower weight per bushel than non-frosted wheat. Green colour in wheat frosted when very immature was observed to change to more nearly the colour of normal wheat if allowed to stand in the field some time before cutting.

Compared to flour from normal wheat, that from frosted wheat was similar in crude protein content, higher in amino

nitrogen

nitrogen compounds, ash, and reducing sugars, and lower in viscosity of acidulated extracted flour-water suspensions. The degree of maturity and severity of frost damage also affected the differences noted. During autodigestion more protein was broken down and reducing sugars formed more rapidly in the frosted wheat flour than in comparable normal wheat flours. It appeared that wheat frosted when containing from 44 per cent. to 46 per cent. or less of moisture, i.e. in the stiff dough stage, could produce as good bread as normal wheat harvested at the same time.

554. Studies of the composition of peas harvested from Alaska plants the seeds of which were sown in succession showed no inherently lower quality in the product of the late sowings, provided the crop was harvested at the proper stage of maturity. The author believes that the low quality product frequently obtained from late plantings is probably the result of a rapid maturity under high temperature conditions. The changes may be so rapid as to cause the latter part of the crop to pass proper condition before harvesting is completed. The author points out that late planting is undesirable because of the material reduction in yield resulting from ripening in hot weather.

555. In studies conducted at the New Jersey Experiment Stations with a view to arriving at an understanding of the relationship between the effects of variable and constant temperatures, the author constructed a piece of apparatus which is here described. Through its use the variables other than temperature have been reduced to zero or at least to a negligible point, permitting direct experimentation with a controlled constant v. a controlled variable temperature.

556. The author has established that in semi-arid and semi-humid regions in the United States the average nitrogen content of the soil increases to the extent of from two to three times for each 10°C., of fall in mean annual temperature. This result was shown to be substantially in agreement with an equation based upon the assumption that organic matter produced by vegetation and its destruction by micro-organisms are determined by climatic conditions. He then proceeds in the present communication from the University of Missouri to present further material collected to support the results already secured, first noting that "after a simple S-shaped curve is assumed for the decomposition process in respect to temperature, and when only soils of similar humidity and similar natural vegetation are considered, the equation takes the form:

$$N = \frac{a}{1 + e^{kt}} \qquad (A)$$

where N represents the total nitrogen content of the soil in per cent., t the mean annual temperature, and a and k, constants". In the present paper are discussed the five new curves yielded by data for humid prairie and humid timber soils, and for semi-humid prairie, terrace, and bottom land soils.

"The nitrogen-temperature curves of these soil groups can all be described by the foregoing formula. In spite of

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this agreement, however, equation (a) represents no more than a first approximation of the true law. It may be considered as a working hypothesis leading to interesting and important practical results. Greater knowledge of the decomposition of organic matter with respect to temperature is needed, and more soil analyses from northern latitudes should be secured in order to determine the absolute validity of the equation."

Further conclusions are represented by the following statement: "In the semi-arid, semi-humid, and humid regions of the United States a correlation exists between the mean annual temperature and the average total nitrogen content of upland prairie and timber soils and of terrace and bottom land soils. The decrease of nitrogen with increase of temperature is exponential or, in other words, the logarithm of the nitrogen varies inversely to the temperature. Generally speaking, for every 10°C. decline in mean annual temperature, the average nitrogen content of the soil increases two to three times. The carbon-nitrogen ratio of the soil organic matter seems to become narrower with increasing temperature".

557. That leaf litter has a profound influence on temperature relations in the underlying soil was shown in studies conducted in a mixed white and red pine forest near New Haven, Conn., during the autumn and winter of 1927, the records being taken at 6 inch, 12 inch, 24 inch, and 36 inch depths.

Litter delayed the freezing of the soil from 3rd December in the open area to 4th January in the litter area. After 4th January the relative rate of frost penetration was the same on both plots, but the maximum penetration in the litter-covered area was 5.8 in. as compared with 8 in. in the bare area. At the same time the character of the frozen soil was affected, that under the litter being porous and allowing water to reach lower levels during rains and thaws, whereas the uncovered soil froze solidly, causing water to run off. Snow was deeper at practically all times on the bare soil.

During the summer and autumn, temperature changes below the surface were less pronounced in the litter area. In winter the snow blanket tended to equalise plots in this respect. Litter raised the maximum, minimum, and mean temperature at all depths during the entire period, the differences being more pronounced in autumn, diminishing during winter, and being quite negligible in spring. At all depths there was observed a distinct diurnal fluctuation in temperature.

558. The importance of measuring soil temperature as well as moisture in experiments with plants is pointed out, and a mercury thermometer and an electrical resistance thermometer for this purpose are described.

559. A discussion, largely theoretical, of plant and soil moisture relationships at moisture percentages approximating the wilting point leads to a considerable number of conclusions among which are the following:

The soil solution being defined as including all of the moisture, available or not available, in the soil, there is a tendency toward a state of equilibrium between the soil and

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the soil solution.

At all percentages of soil moisture, from optimum to an air-dry condition, there is a film of water surrounding each soil particle regardless of its size.

Soils swell or shrink chiefly because of an increase or diminution in the thickness of the gel-like coat which the larger soil grains possess. We can consider the walls of each vesicle in the gel as being covered with a film of water, or the nucleus of each micelle of the gel as being surrounded by a water envelope.

The amount of gas absorbed by a soil is a function of the nature of the soil particle, the area of the surface, and the water content of the soil. Increasing the water content decreases the amount of gas absorbed, with a consequent swelling of the soil if the liberated gas does not all escape.

The forces acting upon water in soils are adhesion, cohesion, and gravitation. The last is relatively important at high moisture contents, but the force of adhesion is by far the greatest at low water contents. Water in a soil always arranges itself so as to be in equilibrium with these three forces.

In soils above the wilting percentage the rate of water intake by plants is sufficient to maintain turgor. As the soil moisture content decreases, the rate of water movement decreases also and when this rate first becomes insufficient to maintain turgor wilting takes place in plants not provided with water storage tissues. The decreasing rate of water movement, or water intake, is caused by two factors. First, the force gradient becomes less, that is, the soil holds the remaining water with an increasing force, which force gradually approaches the force of the plant for water. Second, the level of this force gradient is gradually increasing, causing a decreasing rate of water movement.

The innermost layers of water are held to soil particles with very great force. Each succeeding layer is held with a decreasing force. A measure of the magnitude of the forces can be obtained by freezing-point studies. In such determinations the force of freezing must exceed the force of adhesion in order to produce freezing. From this it follows that very low temperatures are required to freeze the innermost layers of water.

In the inner layers of the soil film, nutrient materials are the most concentrated. The enormous attractive force of the soil particle for water at the wilting percentage may prevent the absorption of water by the plant, but it may not interfere with the absorption of nutrient material. A surface soil that is maintained at the wilting percentage during a great part of the growing season may furnish a feeding ground for plants, although it may contain no available moisture.

The rapidity of absorption of plant food is largely a function of the concentration of the nutrient solution.

At the wilting percentage there is an equilibrium between the plant and the soil with respect to moisture. To a certain extent the plant is probably able to maintain this equilibrium by exuding water from its roots whenever the soil moisture is reduced below the wilting percentage.

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We may look upon the wilting percentage of soils as the water content of the soil when the rate of water intake is just sufficient to maintain turgor. At this moisture content the pull of the plant for water slightly exceeds the pull of the soil for water. The water is held by the soil with a pull of from six to ten atmospheres, or thereabouts. The amount of water held by a soil with this force can be determined by freezing-point methods as well as vapour-pressure methods. These, then, are new indirect methods for the determination of the wilting percentage in soils. The static method in which the soil is placed in a container over a solution of the proper relative vapour-pressure (approximately 99.6 per cent. relative vapour-pressure) is inaccurate because of the great errors due to slight changes in temperature. The dynamic method in which the soil is brought into equilibrium with air having the proper relative vapour-pressure promises to be more accurate than the other vapour-pressure method".

560. Soil moisture determinations to a depth of 10 ft. were made at the Kansas Experiment Station during the seasons of 1926 to 1928 on upland in alfalfa since 1910 and also on land in a 16-year rotation including 4 yr. of alfalfa.

When the alfalfa was on the land the moisture content of the deep subsoil was reduced to a low point and remained almost constant. With most of the rainfall coming during the growing season, the moisture penetrated very slightly below a depth of 6 ft. and was used by the crop about as fast as it came. When the alfalfa land in the 16-year rotation was broken and kept in corn and wheat for 10 yr., the deep subsoil did not gain materially in moisture. On a field in alfalfa for 18 yr. which was broken out early in June, 1928, and fallowed until August, both the soil and the deep subsoil gained rapidly in moisture, whereas other land carrying a crop made no concurrent gain. At least a short period of fallowing would seem valuable to conserve moisture for starting alfalfa.

561. The results of experiments at Goodwell, Okla., on the use of terracing for soil moisture conservation are briefly presented and discussed.

A study of what becomes of rainfall on the heavy type of soil at Goodwell showed that an average of only 3.58 in. of the 17.3 in. received annually soaks into the soil and becomes a part of the permanent body of soil moisture. About 5.41 in. of rain comes in such small showers that it does not add anything to subsoil moisture, remaining in the surface mulch, and being entirely evaporated after a few days. The rest of the rainfall, 11.89 in., may be classified as moderate to excessive and does varying amounts of good as to the building up of soil moisture supplies.

A preliminary consideration of the run-off problem reveals the fact that run-off conditions vary sharply even in different parts of the same field. Very slight inequalities of slope bring about the accumulation of useless surplus water in certain low spots and the injurious lack of moisture in the best drained portions of the field.

Terracing was found to improve greatly the distribution of the moisture, and the cropping results were strongly in favour of terracing.

562. Tests of the groundwater-level on the experimental plots of the Horticultural Winter-School at Lisse, commenced in April 1923, revealed an entirely unexpected variability. Further tests confirmed the fact that the groundwater-level may display considerable fluctuations in a short time, which are connected with the weather conditions, especially with the rainfall and the investigation was continued with the aid of recording level gauges, so that an accurate idea of this connection might be obtained.

The gauges were copper cylinders of 30 cm. diameter, and 70 cm. to 1 m. high, perforated along the lower half. One of them was at the side of a ditch, and two at a distance of 7½ m. and 15 m. respectively from it.

The floats in the gauge-pipes displayed great fluctuations with a slight rainfall which had no demonstrable connection with the level of the water in the ditch, and could not have been influenced by this, inasmuch as a sudden rise of the float was found to be possible with a falling ditchwater-level.

The water-level in the gauge-pipes rose practically simultaneously as soon as the rain had fallen, and to a greatly increased extent compared with the height of the rainfall, and then again fell much less steeply. These rises were, in the cases under consideration, from 25 to 40 times as great as the rainfall, but may be more than 60 times as great.

The conclusion which is drawn from this, and about which there would appear to be no difference of opinion, is that the rain penetrates into the ground by means of capillary action, and shuts off, as it were, the air beneath it as with a lid, and to a certain extent compresses it.

The author asserts that the interpretation given by MEZGER and HEYMANN that the consequent rise of the water-level in the gauge-pipes takes place under the direct influence of the increased air-pressure, in the same way as in piezometric tubes into which a liquid flows under pressure, is incorrect and he advances an alternative explanation.

Out of a zone in which the ground-water is under hydrostatic or, more generally speaking, under hydraulic pressure, the water rises by capillary action in the capillary cellular system until the surface tension in the menisci which form the upper limit of capillarity is in equilibrium with the gravitation, i.e. the weight of the liquid capillary columns. In this zone there is thus a pressure smaller than the atmospheric pressure, i.e. a negative pressure. Below this is the water under hydrostatic, i.e. a positive pressure, and between the two is situated the boundary surface, in which there is zero pressure, and which is known as the phreatic surface. This is the surface which corresponds to the level of ground-water, and with which the water in a hole that has been dug or in a stand-pipe agrees, except when it is also under artesian conditions.

For the present purpose it is assumed that initially there is only air in the soil above the capillary zone. Now, if rain falls over an area of any importance and is sucked into the soil by capillary action, then a heightened air-pressure is produced in this zone, say equal to h_1 water pressure (more than the atmospheric pressure). The state of equilibrium between the water-lid and the phreatic surface

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is destroyed, as the surface tension in the menisci now has to reach equilibrium with a pressure above it equal to h_1 water-pressure and the weight below it of the column of liquid of the capillary zone. There will again be equilibrium when both together are equal to the capillary rise of the kind of soil. This means that the phreatic surface rises through a height h1; at the same time a static change occurs, i.e. a change which is not accompanied by any displacement of water. From this moment onward the water from the zone below the risen phreatic surface penetrates into the gauge-pipes until the water-level in them is on a level with the phreatic surface. The levels shown by the recording level-scales at Lisse are thus really ground-water levels.

It is evident why the phenomena under consideration may be of such great practical importance. For when the phreatic surface rises to a comparatively great extent on the penetration of slight quantities of rain, then the roots of plants will be able to benefit by this, even if only for a short time, and it might be possible to ascertain whether, in bulb growing districts where, according to the statements of cultivators, the reckless drawing of drinking-water from the dunes has appreciably lowered the level of the ground-water, favourable results might be obtained by means of artificial rainfall over a sufficiently large area. Cuttings such as deep trenches and ditches will in that case have to be prevented in the experimental fields in view of the escape of air.

The phenomena also throw a new light on Volger's condensation theory, to which perhaps more practical importance will have to be attributed than has hitherto been done. This could be ascertained at the same time by means of observations of moisture content of the air at Lisse.

563. Those studies, particularizing the physiology and developmental behaviour of Phaseolus vulgaris, Soja hispida, and Amaranthus retroflexus under controlled conditions, are said to have shown the dry weight product in plants grown in moist air to be greater than that produced under dry air conditions. Both water content and guard cell behaviour may be significant in this connection. The water requirement was greater in dry air. The behaviour of different plants is discussed. The dry air plants showed such xerophytic characters as smaller cells, more stomata per unit area, and denser veining. The damp air plants transpired more readily in response to external factors.

564. Winds averaging around 15 m. p. h. in velocity were found to produce a 10-day delay in the maturing of crops which had a 60-day growing period and also reduced yields.

565. Comparative study of mesophyll development in plants situated similarly except with relation to light incidence is said to show a mesophyll development 77 per cent. greater in strong light than in a shady situation. The palisade cells show more rows and greater length. The cells of the spongy parenchyma are more numerous. The epidermis is thickened.

Illumination

Illumination shows less influence on the vascular bundles, which develop only about 26 per cent. more substance under illumination. The increase in the shadow is due principally to an increase in mechanical elements.

The development in the size of the epidermal cells is inversely proportional to the light absorption. The coefficient of enlargement of the epidermal cells under a set of conditions in shade is comparable to that of the enlargement of the leaf as a whole. Regarding the influence of light in comparison with shade as expressed in the increase of stomata, this appears to be only about 1 per cent.

566. The authors point out that even if light can not be shown to exert an immediate influence on the development of the underground part of the plant, the root system clearly reacts to differences and changes in the light relations of the above ground parts. Plants cultivated in full sunlight develop a significantly larger root system than do plants grown in the shade. The stimulating effect of light on the development of the root system is clearly altered after the removal of growing plants from shade to sunlight. The stimulatory effect of light shows itself clearly in the development of the water-conducting elements, and this phenomenon is thought to be connected with the elevation of temperature in light.

567. Studies at the Indiana Experiment Station indicated a high positive correlation between the number of sunshine hours and the number of days required for tomatoes to ripen after they had started to colour. The coefficients of correlation for 4 varieties ranged from a minimum of 0.4 ± 0.66 to a maximum of 0.68 ± 0.053.

568. Observations on strawberries brought into the U.S. Department of Agriculture greenhouses at Washington, D.C., in late autumn showed strikingly different variety responses. Missionary and Klondike resumed growth at once, although the latter made the stronger leaf growth. Howard 17, on the other hand, made practically no growth. Under artificial light, which prolonged the normal day to 10 p.m. (20th October to 19th January) Missionary responded more quickly than did Klondike, with Howard 17 showing almost no response.

Apparently certain varieties had no rest period. In some cases varieties which failed to respond to light increments in late autumn or early winter did respond when brought in on 1st February, but varieties of Alaskan and English origin were slow to respond even at this late date. The authors suggest that light response in the greenhouse may be useful in determining the regional adaptation of seedlings and new introductions.

569. In view of the fact that the Peking variety of soy bean grown in light-lacking waves of the violet-blue range lengthen and twine excessively, while plants under the same

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total intensity of light having all the wave-lengths of the solar spectrum gave no such response, the present study was instituted to determine whether similar effects could be produced by decreased intensity alone, the plants receiving all rays of the spectrum at greatly lowered intensities. Four varieties of soybeans were grown under 6 different intensities, averaging 4,285, 1,536, 560, 390, 250 and 26 foot-candles respectively.

It was found that the lower the light intensity, the more rapid the stem elongation during the initial period of growth. The greatest range of height was attained by plants under a light intensity averaging 560 foot-candles, and the lowest, under an average of 26 foot-candles. Stem thickness was directly proportional to the light intensity, being greatest under 4,285 foot-candles and least under 26 foot-candles. All of the plants were unusually long-stemmed. Those receiving most light showed the greatest vigour and the best leaves, colour, and fruit. A gradual falling off in these respects corresponded to a decrease in light intensity. Plants under 26 foot-candles became completely etiolated and died in from 3 weeks to 4 weeks.

Twining occurred in all plants under light intensities from 250 to 1,536 foot-candles, but not over 4,285 foot-candles or under 26 foot-candles, In soybeans a latent factor for twining appears to be associated with stem length and thickness. Thick stems require a greater length for twining than thin ones, but in no case did twining occur in a stem less than 35 cm. high.

"The curves of growth in length of all plants except those in the darkest compartment followed the general curve of a monomolecular autocatalytic reaction. The autokinetic phase of the curves appeared to be associated with the initiation and development of indepedence in the seedling brought about by the ascendency of photosynthesis, while the falling off in rate during the latter part of the autostatic phase was caused by the development of flowering and fruiting."

570. Prefaced with a general discussion upon solar radiation and its physiological effects on plants, upon methods and instruments employed in measuring solar energy concerned in photosynthesis, and upon the results of pertinent experiments, this bulletin reports the results of experiments conducted at New Haven, Conn., and Keene, N.H., upon the light requirements of white pine, red pine, hemlock, red oak, and chestnut oak. The general conclusion is drawn that the intensity and quality of the light reaching the forest floor are not the determining factors in accounting for the nature of reproduction in fully stocked forests such as obtained in the study. The species under study survived for 10 months under a light intensity that was not over 300 foot-candles at any time. For white pine seedlings approximately 170 foot-candles were required to balance the carbon dioxide lost in respiration and used in photosynthesis, and an additional 170 foot-candles was apparently sufficient to maintain growth. The intensity of light under white pine canopies in the Yale Forest was found to be in excess of the minimum requirements of the seedlings tested. The tree seedlings lived and grew under various ranges of the visible spectrum provided they were supplied with adequate light intensity.

571. When digitalis was started under glass that transmitted ultra-violet light and the plants were later transplanted to the field, it was found that digitalis developed a higher potency under the influence of the ultra-violet transmitting glass. Solarisation for one year did not appreciably affect the transmission of the particular portion of such rays as are responsible for such effect in digitalis.

572. Since the report by Johnson on increased tuberization of potatoes caused by X-rays, the authors conducted an experiment in which the findings were contrary to those indicated by him. Certified seed of Irish Cobbler and Green Mountain varieties were used.

One half of each tuber was irradiated, and the other half was left untreated as a control. One lot of half tubers was irradiated for 10 min. and a second lot for 5 min. Sprouts were just beginning to develop at the time of exposure, and the tubers were planted in the field on the following day. Each seed piece was cut to a weight of 30 gm., using the bud end, and the pieces were spaced 9 in. in the row.

Plants from the lot of tubers receiving the 10 min. exposure produced only 84.4 per cent. as many tubers of all sizes as the untreated controls, and only 89.6 per cent. as many tubers weighing over 45 gm. each. The total weight of all tubers was reduced 6 per cent. by the treatment. Plants from the lot of tubers irradiated 5 min. produced 104.7 per cent. as many tubers of all sizes as the controls, and 105.1 per cent. as many tubers weighing over 45 gm. each. The total weight of all tubers was increased 3 per cent. by the treatment.

The 10-minute irradiation caused some injury to the first leaves, but the subsequent leaves of the plants were normal. After the formation of normal leaves the plants were vigorous and remained green several days later than untreated plants at the time of maturity. No striking abnormalities resulting from irradiation were noted in the harvested tubers. Irradiation for 5 min. produced no apparent modification of plants or tubers.

Summarizing their results, the authors claim that strong doses which cause definite lesions on leaves may also reduce the number of tubers formed, but such tubers may attain a greater size, so that the yields of marketable stock may not be lowered.

573. Six 500-watt lights were suspended directly over a block of 15 trees consisting of several varieties of apples. The plot was flooded with light each evening for 2.5 hr. to 3 hr. from 26th April to 30th June, i.e. to the end of the first brood of codling moth. Temperature for the period was recorded, the foot-candle meter readings were made to ascertain light intensities. Comparing fruit of the same variety at the end of the test it was found that 21 per cent. of the apples on check trees outside the test plot were attacked by moth, while only 14.5 per cent. of the apples inside the test plot were so affected. Light of the intensity and quality used indicates a tendency to deter the codling moth in its egg-laying habits.

574. The authors find that the virus of foot and mouth disease in filtrates is destroyed after 5 minutes' exposure to the radiations of the mercury-vapour lamp in quartz flasks, which transmit radiations of wave lengths from 5,720-2,300 Å.u. It is inactivated after 30 minutes' exposure to the rays of the mercury vapour lamp filtered through a sheet of Vitaglass which allows the passage of rays of wave lengths from 5,720-2,800 Å.u. The rays of wave lengths 5,720-2,300 Å.u. have no lethal action on the virus of foot and mouth disease. When the virus was suspended in unfiltered lymph or serum, a protective action due to selective absorption by the suspending fluid was observed.

575. It is pointed out that conditions within or near the plant cover may be quite different from those at levels or places unaffected by the cover. It is stated that reliable conclusions regarding the relation of meteorological conditions to crop-growth can be drawn only from observations made in close proximity to the crops. The plan for observations on the diurnal course of the meterological elements during the growing-period of crops, which were begun at the Poltava Experiment Station in 1927, is described.

576. Of the weather factors, rainfall is at Rothamsted the most important in determining total yield, both the amount and distribution having great effect. For wheat, winter rainfall is harmful; for barley it is beneficial at Rothamsted, but not, apparently, on the lighter soils of East Anglia. Spring rainfall - January and February on the light soils in East Anglia, and March and April on the heavy soil at Rothamsted - is harmful to barley but not to wheat, July rainfall benefits barley but not usually wheat. The effects, however, depend on the manurial treatment, and indeed one of the practical results of the investigation is to show the kind of treatment that would be most effective in seasons of various characters.

Up to the time of ripening, temperature is less important so far as the total growth is concerned, and hours of sunshine still less. Plant physiological work in the laboratories has partly explained the relatively small effect of temperature on the total growth of the plant. It appears that low temperatures tend to increase the size of the leaf but to reduce the amount of plant substance each unit area can make, while the higher temperatures tend to reduce the size of the leaf but to increase the amount of plant substance made by each unit area. As a result of this compensating action the yield varies less than might be expected from changes in temperature.

The position is altered however as soon as ripening begins: vegetative growth then slackens greatly or entirely ceases. High temperature hastens the setting in of this change, and if it comes early it may cut short a period of very active growth, so lowering the yield: for example, high temperatures in May and June reduce the yield of barley.

577. A pure line of Sixty-Day oats was grown co-operatively

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at the Montana Experiment Station and the New York Cornell Experiment Station from 1912 to 1919, inclusive. From 1915, onwards, seed was exchanged by each station for comparison with locally produced seed. The data on a number of characters were analysed biometrically to determine the changes, if any, effected by growing the oats under widely different environments.

The New York soil contains 50 per cent. more organic matter and slightly more phosphorus than the Montana soil, while the latter, more favourable for cereals, contains over four times as much calcium and about twice as much potassium as the New York soil. As represented by the stations, New York has more degrees of growing temperature during the growing season, while Montana has more daylight hours, a higher percentage of daylight hours with sunshine, and the higher daylight-sunshine-growing-temperature factor. The climatic conditions favour heavier growth in Montana than in New York.

The oats plants grown in Montana were generally larger and produced more culms and more grain. However, this increase was not permanent. The nature of the variability of plants produced under the different environments was practically the same. In some instances the variability was greater in New York than in Montana, e.g., in the average number of kernels per culm and the average weight of kernels per culm, whereas higher variability for the average weight of kernel was obtained with the Montana grown plants. These changes in variability were caused by such factors as the different environmental conditions, which affected the means of standard deviations, causing higher or lower coefficients of variability.

The correlation of characters was affected by the different environments more noticeably with certain characters than with others. The correlations between total weight of kernels and average weight of kernel and between the average length of culm and the average weight of kernel were higher in Montana than in New York. Certain correlations were found to be high and stable, while others were very unstable, being affected equally by environment either in the same locality in different years or in widely different localities. Correlations obtained with the plants grown from imported seed tended in general to agree rather closely with those from plants from home-grown seed. As a general conclusion, environment appeared to be more important than source of seed.

578. These notes relate to preliminary results obtained with maize by use of methods similar to those previously used with sugar beet, the maize plant having been shown previously to be comparatively independent of climatic influence as regards composition of the grain.

While sufficient grounds were not obtained for imputing to the differences in composition which are found to be the chief cause of stability of corn and sorghum against climatic influences, it is thought that "it may be ultimately important to consider that sucrose and less soluble forms of protein are quite likely to be less altered by the effects of temperature and other climatic factors than are such reactive compounds as glucose, soluble proteins, and other soluble nitrogenous compounds".

579. Experimentation proved conclusively that curly top virus introduced into tomato plants by Eutettix tenella may under specific environmental conditions cause a condition indistinguishable from tomato western yellow blight. Though it was practically impossible to attain the complex of field symptoms in the greenhouse, particularly with the caged plants, perfect blight specimens were obtained in tomatoes grown outdoors without protection or in light muslin cages.

Shading retards the disease and partly prevents its progress. Though under heavy shading certain field characters of the blight are lacking, the curly top symptoms are rendered more conspicuous. Light and humidity appear to be the most important separate factors in the development of the complete field symptom complex. High temperature may shorten the incubation period, but it cannot without the proper heat and moisture cause the blight complex. Such factors as age may strengthen or weaken the plant's resistance to blight.

It is suggested that, for the purpose of brevity, of conforming with the facts, and of including similar diseases of other crops, the name tomato western yellow blight be changed to tomato yellows.

580. Experiments at the Indiana University with eight species of Crocus placed in electrically controlled chambers, described in detail, showed that the flowers of the species C. vernus when at the proper stage of development may respond to changes of temperature of less than 0.5°C. In fact, increases of 0.2°C. caused perceptible opening of the petals. In the case of Tulipa no flowers responded to changes of less than 1°C.

581. This experimental work on the destruction of the European corn borer in ear corn in 1922-24 was conducted with a view to permitting shipment of seed corn on the cob into uninfested territory for exhibition, etc.

In work with borers unprotected by the cob - in which they most commonly occur - it was found that all larvae were killed in 5 min. at constant temperatures of 68°C. and 70°C., and in 6 min., 7 min. 9 min. 11 min. 13 min. and 15 min. at constant temperatures of 64°C. and 66°C., 62°C. 60°C. 58°C. 56°C. and 54°C., respectively, whereas lower constant temperatures seemed to be ineffective in killing them.

Detailed studies made of the time necessary to kill larvae at constant temperatures of from 58°C. to 66°C., found to be most effective in the first tests, resulted in obtaining complete kills at the following constant temperatures with the periods of time specified: At 66°C. in from 4 min. to 6 min., at 65°C. in from 4 min. to 6 min., at 64°C. in from 4 min to 7 min., at 63°C. in from 5 min. to 6 min., at 62°C. in from 5 min. to 8 min., at 61°C. in from 6 min. to 7 min., at 60°C. in from 6 min. to 9 min., at 59°C. in from 5 min. to 10 min., at 58°C. in from 8 min. to 10 min. These experiments indicated that considerable variation in suspectibility to heat was characteristic of hibernating larvae of this insect, some individuals being killed more readily by a certain degree of heat than are others. In each of the experiments 10 larvae were enclosed in the cheese-cloth cage during the test.

In

In determining the rise of temperature within the centre of the cob special chemical thermometers of about the thickness of an overwintering corn borer larva were obtained, and these were fitted into the insect's burrow in the cob without unduly enlarging the hole and so interfered as little as possible with the natural protecting insulation of the cob. The results are presented in detail in chart form, curves showing the rise in temperature within ears of Golden Bantam sweet, Longfellow flint, Brewer Yellow dent, and Queen Golden pop corn when subjected to constant temperatures at 40°C. 50°C. 60°C. and 70°C. Examination of the curves shows that although the temperature within the ears was raised considerably it was still below the constant temperature of the heating chamber after a 2-hour period. A continuation of the heating showed that usually more than 5 hr. was necessary to bring the temperature of the centre of the cob to the temperature of the heating chamber. The rise of temperature within the cob was quite rapid during the first hour of heating, much slower during the second hour, and thereafter was very slow.

An examination of certain of the factors influencing the rise of temperature within the ear showed that within well-dried ears it rose with considerably greater rapidity than within wet or moist ears. The kernels were found to be important insulating agencies, inasmuch as the temperature in the centre of cobs from which the kernels had been removed was raised much more rapidly than the temperature in the centre of cobs on which the kernels remained.

Details of the killing point of larvae of the European corn borer determined by heating ears of corn at several constant temperatures for various periods of time are presented in tabular form. Larvae in the ears of any type of thoroughly dried corn were found to be killed at the following temperatures not injurious to the grain at 58°C. in 24 hr. 60°C. in 8 hr. 63°C. in 5 hr. 66°C. in 3 hr. and 68°C. in 2.5 hr.

Preliminary experiments in heating infested ears of corn so as to kill the contained larvae showed that to do this successfully in the shortest possible time the ears may be placed in single layers on trays the bottoms of which are of screen wire, such as 1-inch mesh chicken wire. The trays should be arranged on racks in the heating chamber in such a way as to allow free circulation of air about the ears. The heating period should be measured from the time the container reaches the desired temperature after the ears have been introduced.

"The heating of ears up to 68°C. for the periods of time studied was not found to affect injuriously the subsequent germination of the seed, or the growth of plants, or production of ears from such seed. The moisture content of the ears used was not determined, and for this reason the safety of such temperature may be questionable except in the case of thoroughly dried ear corn".

582. In studies conducted with larvae of Lucilia sericata Meig., in which temperature changes were controlled and measured, it was found that the rate of locomotion varied directly as the temperature from the low limit of activity, about 2°C., to about 40°C., and inversely above this point. The rate of contraction increased directly with temperature from 0°C. to 45°C. The number of contraction waves made by a maggot in travelling a given distance, as 10 cm., was a constant between the temperatures of

10°C.

10°C. and about 33°C., which means that the height of contraction of the maggot is the same within this range. Above this temperature optimum and below it the height of contraction decreased. This caused the rate of locomotion to increase up to a point where the loss of height of contraction was greater than the gain from increase of rate of contraction.

583. Experiments are reported in which citrus fruits were inoculated with cultures of a number of fungi and the rate of decay, as influenced by the species of organisms and temperature of fruit after inoculation, was determined.

"When inocula containing certain mixtures of spores were used the rate of decay greatly increased; when inocula containing certain other mixtures were used the rate was lower than when any one of the components of the mixture was used alone; and when inocula containing still other mixtures were used the rate approximated that of the most rapid component acting alone. With most mixtures temperature had an important influence on decrease or increase in rate.

"A mixed inoculum containing spores of Penicillium italicum and P. digitatum gave increased rates of decay on lemons at the higher and lower ends of the temperature range. The mixture also produced a reddish discoloration of the decayed tissue.

"A mixed inoculum containing Aspergillus niger, P. italicum, and P. digitatum produced at the lower temperatures higher rates of decay than the highest rate of any one of the fungi alone.

"Oospora citri-aurantii in mixtures with P. italicum and P. digitatum caused greatly accelerated rates of decay, especially on lemons, where at low and intermediate temperatures the rate was more than the sum of the rates produced by the fungi alone.

"Botrytis cinerea in mixtures with P. italicum and P. digitatum appeared to have a depressing effect on the rate of decay.

"In other mixtures B. cinerea appeared as a rule to have a depressing effect at low and intermediate temperatures, A. niger to have an accelerating effect at intermediate and high temperatures, and C. citri-aurantii to have an accelerating effect at nearly all temperatures."

584. These experiments were carried out at variable and at constant temperatures, not lower than 14°C. the results obtained being compared. The maximum temperature for the development of the egg was found to be a little higher than those for the larval and pupal stages. Continued exposure to a constant temperature of 33°C. or higher appears to be injurious to any stage of the insect, and the death rate at 33°C. sometimes exceeds 70 per cent. The mean value of the accumulated temperatures of the egg stage is 63.4°C. degree days, that of the growing stage 153.9°C. degree days, and that of the cocoon period 142.7°C. degree days.

Taking

585. Taking seeds directly from fruits and planting them in jars of sand kept uniformly moist and held at various maintained temperatures with light supplied artificially after germination, the author found that the optimum range for sweet orange germination and early growth was from 75°F. to 85°F. and for sour orange from 75°F. to 80°F. At 55°F. no sweet orange seeds germinated in 105 days, but sour oranges showed some germination in 90 days. No seed of either species germinated at a constant temperature of 104°F.

586. From observations made on the experimental field at Dahlem (Berlin) in the course of January and February, 1929, it would appear that not only is the temperature under the snow in cold weather sensibly higher than in the air or on the surface of uncovered soil, but that it is much more regular, a point which is not less favourable to young plants than a less rigorous spell of cold weather.

587. The relationship of initial soil moisture to spring grain (oats), grain sorghum, and winter grain, (winter wheat) was studied at the Panhandle Station during the period 1924-28.

Although the climatic conditions do not favour spring grains very consistently, it seemed that these crops can be used very profitably when moisture is adequate in early spring. The omission of spring grains, except under favourable conditions, is advised. The influence of initial moisture on the effectiveness of fall preparation for summer crops and in regard to the spacing of grain sorghums appeared sufficient to make it of value in planning.

Fall preparation is advised except when a severe drought exists at the contemplated time. Varying the planting rate for grain sorghums according to the soil moisture present at the time has given highly satisfactory results. With wheat, the initial moisture conditions were not found of great importance, except for the stand and overwintering without drought injury, and the limited data prevent a dependable forecast of crop results.

588. The most severe drought during the years 1911 to 1928 at Goodwell covered the period from October, 1926, to May, 1927, during which the average monthly rainfall was 0.37 in. and resulted in complete failure of small grains. In the preceding year high yields were obtained from all types of crops. The performance of 14 crop rotations on silty clay soil for these 2 years of extreme conditions is presented.

The ability of the soil type to retain a large supply of moisture through protracted droughts was demonstrated. On land containing much available moisture, deep tillage during the drought materially reduced the quantity present when the drought ended. The cropping previous to the drought affected the quantity of soil moisture present and carried through the dry period. Listed in the order of the quantity of soil moisture

present

present in May, 1927, the cultures were summer fallow, cowpeas, corn, wide-spaced sorghum, close-spaced sorghum, small grains, sweetclover and alfalfa. Cropping plans which maintained a soil moisture reserve through the drought of 1926-27 also carried through a good supply of nitrates. The highest average yields during 1927 came from rotations passing through the drought with moisture and fertility reserves and from rotations including large areas of adapted summer crops.

589. Data are presented upon the amount of precipitation intercepted by the foliage of trees, upon comparisons of run-off before and after deforestation of given areas, upon seasonal variation in soil water, in the forest, etc.

590. Pointing out that many factors, such as run-off, seepage, surface evaporation, water used by ground cover plants, the amount of rainfall at a given time, and the density of the stand, are involved in the amount of soil water available to a tree, the author presents diameter increment data from thinned and unthinned plants located at various points in the State, all of which tend to show that under comparable conditions trees of the same original diameter failed to make similar gains in growth. It is assumed that trees of a forest species, like those of a cultivated form, undoubtedly vary in their response to environment.

As an example, in an analysis of records taken on 18 dominant white pines in the 10-inch class growing under identical conditions of rainfall the increases over an 11-year period when expressed in the percentage of the slowest growing trees were 100, 263, 263, 410, 515, 558, 600, 600, 600, 684, 684, 726, 768, 768, 768, 810, 853, and 1,021. Similar variations were observed in the trees of the several experiments and were not confined to any one species. Attempts to calculate rainfall from diameter growth by dividing the total rainfall of the 11 years by the average increase of all trees in each diameter class were wholly unsuccessful. Some indication was obtained of a correlation between diameter gain and the amount of space available to the tree, especially in stands where root competition was not present.

591. Lysimeter equipment built in 1922 is described at some length.

With the additional assistance of rain gauges which showed the total quantity of water added by precipitation and permitted also the determination of its content of plant food elements, it was found in the course of 3 years that there was an average annual gain in 1 acre from atmospheric sources of 3.78 lb. of nitrogen, 37 lb. of calcium (calculated as carbonate), and 13.19 lb. of sulphur. The corresponding average annual losses of the same 3 elements from 1 acre by leaching were calculated as 46.12 lb. 166,87 lb. and 15.01 lb. respectively.

592. Experiments at the Dahlem Horticultural Station with various plants grown under ultra-violet, common window glass, and crude glass gave varying results. Based on 100 per cent. yield for plants under the crude glass the maximum yields per cent. under ultra-violet glass for radish, spinach, lettuce, bush beans, cauliflower, melons, tomatoes and carrots were, respectively, 110, 123, 107, 121, 95, 96, 109 and 95. The rooting of tomato and Cotoneaster cuttings were slightly less under ultra-violet glass. In the case of the tomato early ripening was stimulated by the ultra-violet glass. Records taken of the temperature under the three types of glass showed slight differences which were overcome by ventilation. It is suggested that the differences in responses of the various plants may have been due to their behaviour under various light intensities.

593. Investigations of the attraction of moths to lights of various intensities in light traps have led the authors to recommend this as one of the most effective means of combating Chilo simplex, a very destructive enemy of the rice plant. It was found that light exercises a greater attraction to the moths before than after midnight. The females are more strongly attracted to light before midnight than are the males, but after midnight the reverse is true. A high rate of attraction to the light is shown by the females one or two hours after sunset, and by the males one or two hours still later. The attraction to the light reaches a high rate in the females at about the time mating and egg laying begin, and in the males at about the time that mating is accomplished. The moths, when in a certain physiological state, are generally attracted to the light at a high rate; this attraction appears to be of a secondary but not of a primary character.

594. This article discusses results of studies with rye from 1886 to 1919, inclusive, at the phenological observatory at Sirotkino, near Moscow. It indicates that a mean daily temperature of about 20°C. with a diurnal amplitude of 10°C. or more and a mean daily humidity of from 41 per cent. to 60 per cent. are especially favourable to the growth of rye if not accompanied by droughts.

595. Generally speaking the proposition holds good: light creates scent, warmth and sugar. Nevertheless, it is known that plants are able to adapt themselves to shorter growth periods, e.g. barley when transferred from southern to northern but clearer, climates. The necessary amounts of heat remain constant for each variety approached and in this relation important differences are encountered amongst acclimatised Norwegian varieties. With potatoes the height of the tuber yield increases in proportion with an increasing amount of warmth to a relatively high peak. The increase does not mount in the same manner with all varieties. Early quick-growing varieties are able to sprout with a relatively small amount of warmth, whilst later varieties need a greater amount of warmth. On the contrary by raising the average day temperature, the dry matter content is increased. With summer-grown varieties the total yield increases, principally in straw, with an increasing average day temperature. The corn harvest increases similarly with the

increase

increase of the average day temperature during the whole growth period until this attains the peak of 12°C to 13°C. For each variety or strain of plant the necessary amount of heat is the same in all climates, and it is therefore not absolutely essential whether it comes through a longer growth period with a medium day temperature throughout or through a shorter growth period with higher day temperature conditions. From this it will be seen that the necessary amount of warmth is the essential element of the variety characteristics, indeed the growth generally is discontinued at a known minimum temperature as well as at a definite maximum temperature. By this a limit is set to the possibilities of the late varieties existing in higher altitudes. On the basis of this theory formulae would be derived which, given a knowledge of the probable total heat and the average day temperature, would make it possible to forecast in advance the coming harvest. To prove the accuracy of these deductions, the author has taken measurements of growing plants, and has thereby found that the resulting curves correspond relatively closely with those of von Boussingault and others.

596. 1.*All varieties of oats, as well as of Vicia villosa, investigated by us, belong to the spring forms, according to the common terminology, i.e. they are able to bear fruits in the first season when spring sown. Nevertheless, we have succeeded in detecting among them such forms which, under the influence of chilling on early stages of development, are able to shorten their vegetation period considerably, thus approaching winter forms. Such shortening of the vegetation period under the influence of chilling endured on early stages of development, we have termed the after-effect of temperature.

2. The after-effect of temperature shows itself chiefly in the late forms of oats and hairy vetch. The shortening of the vegetation period may be so considerable that they not only overtake, but even outstrip the earlier forms. Along with the shortened vegetation period, the character of growth changes. The number and dimensions of the vegetative organs decrease and in result the total yield, as well as the yield in grain, are reduced. Thus, through chilling on early stages of growth, the later but more productive forms turn into earlier, but less productive ones.

3. The nature of this after-effect of low temperature may be seen from the fact that, similar to the winter forms, the late varieties investigated by us possess on the early stages of development a kind of check retarding their transition to the reproductive stage. Under the influence of chilling this check disappears and the plant rapidly begins to bloom. We do not think, however, that late maturity is always determined by the presence of such a check, as there are late forms exhibiting no after-effect of temperature.

4. We regard the late varieties responding to the influence of cold as transitional ones from spring to winter forms, the latter possessing a still more powerful check making impossible their flowering in the first summer, under conditions of the usual spring sowing. In our opinion, the chief difference between the spring and the winter forms lies in the fact that typical spring forms come into bloom unhindered, under all temperature conditions, while the typical winter forms require a prolonged influence of low temperature. The transitional forms

come

come into bloom in both cases, but under the influence of lowered temperature, they considerably shorten their vegetation period. The existence of such transitional forms confirms the previous statement of Maximov and Pojarkova (1924) that the difference between winter and spring forms is not qualitative but only quantitative.

597. *A trial was made of different methods of protecting young orange trees from frost.

It appeared that:-

(1) Wrapping a few thicknesses of newspaper round the stem gave very effective protection.

(2) Mounding soil up round the stem was effective protection to the stem, but increased the injury to the branches.

(3) Protecting the stem with a cylindrical wire-netting frame 3 inches in diameter covered with hessian was less effective.

(4) Placing a hessian bag either tarred or not tarred over the tree was distinctly detrimental.

It is felt, however, that further trials could be carried out with advantage.

598. Longitudinal growth of the uppermost leaves is much better at 31°C. than at 35°C. It is somewhat retarded at 37°C.-39.5°C. though when the plants are placed at 30°C. the original growth activity is partially restored. At 41°C.-43°C. the growth is minimum, and at 45°C. it nearly stops. The growth is much better at 30°C. than at 25°C. and at 21°C. than at 17°C. At 7°C-8°C. growth nearly stops, though if the plants are placed at a higher temperature, it begins again. The curve representing the growth variation differs in its form from that representing the variation of air temperature and resembles rather that of the variation of soil temperature.

599. (1) The heat sums do not express the absolute requirements of the plant with regard to the amount of heat. The amount of heat required by the plant is connected with its requirements regarding a certain number of light-days, determined by the duration of the separate days. On the other hand, the number of light days required by the plant depends on the amount of heat.

(2) As in the majority of cases vegetation begins about the same time, the light factor in a given geographical station remaining the same from year to year, is of no decisive importance as regards the time of flowering. The latter is determined by temperature. The amount of heat required for flowering may be determined by way of summing up the average diurnal temperatures, at least on those co-ordinates where the time of flowering is in direct dependence on the amount of heat. In the same station, the heat sums accumulating by the time that flowering of a given species sets in, represent a magnitude more or less constant in the separate years. The author regards the heat sums as the amount of heat required for the completion of the preparatory period before flowering under conditions of day-length, peculiar to the given locality.

(3) With the variation of day-length, vary also the heat sums, but besides temperature flowering is determined also by the length of the day. Therefore a constancy of heat sums in the same station for the separate years may be expected in the majority of cases, but what must not be expected, is the constancy of heat sums of the same plant in different geographical co-ordinates.

600. Observations upon the seedlings of 13 species of conifers grown in receptacles containing dark adobe soil covered with a thin layer of coarse sand and exposed directly to a radiant electric heater so tilted that the rays struck the surface of the soil at an angle of 65° showed very definite relations between injury and the temperature within the seedlings, as determined by the electric thermocouple. The age of the seedlings and the species were also factors concerned in injury. Characteristics tending to reduce injury from heat were (1) large cotyledons, (2) short hypocotyls, (3) rapid development of the true leaves, (4) large stems, (5) rapid development of the endodermis and xylem, and (6) an early change of cortex from succulent to hard tissue.

The living tissue of seedlings from 1 month to 3 months of age was quickly killed at 130°F. or higher but was able to withstand somewhat lower temperatures for some time. Heat injury ranged from a slight discoloration on the exposed surface to the complete killing of an entire ring and was rather difficult to distinguish from damping-off injury. Under the conditions of the experiment the tissues of the seedlings remained on the average from 15°F. to 20°F. cooler than the surface sand temperature, with a maximum difference of 42°F. and a minimum of 0°F. The temperature in the base of the seedling was evidently influenced very materially by the amount and position of the shade cast by the foliage. Hardening of the stem tissues tended to reduce injury as the plants became older.

601. Comparing the effects of 5 days at 0°C., 10°C. and 20°C. on the development of hardiness in elm seedlings, as measured by the results of 24 hours' exposure at - 5°C., it was found at the Minnesota Experiment Station that 0°C. was decidedly most effective in promoting hardiness. In the 0°C. lot top branches were killed on only 10 per cent. of the seedlings, at 10°C. all of the seedlings lost their tops but buds at soil level survived, while at 20°C. 96 per cent. were killed. Alternation from 0°C. to 20°C. resulted in less injury upon subsequent freezing than did continuous exposure at 10°C. However, very frequent alternations (0.25 hr., 0.5 hr., and 1 hr.) did not induce as great hardiness as did exposures for 2-hr., 4-hr., and 8-hr. intervals, presumably because the shorter exposures failed to lower the temperature in the seedlings on account of temperature lag.

602. The results (which are fully described) of experiments conducted at Coatesville, Pennsylvania, to determine the effect of temperature on the growth, pathogenicity and control of Mycogone perniciosa, the causal organism of the bubbles disease of edible mushrooms showed that the minimum, optimum and maximum temperature for the development of the fungus are 8°C., 24°C. and 32°C., respectively. The temperature range at which the most active growth occurred, viz. 21°C. to 28°C., is higher than that to which the mushrooms are normally exposed during cultivation. The results of tests to ascertain the relation of temperature to infection by M. perniciosa showed that infection regularly succeeded in the cultures kept at 21°C. and 15°C. but only occasionally at 10°C. In agar cultures the fungus was killed by exposure to a temperature of 42°C. or above for six hours or more. The bubbles disease did not develop in mushroom cultures in artificially infected damp soil that had been subjected to temperatures of 45°C. and 52°C. for 12 hr. or 24 hr.; all the control cultures contracted infection, which also occurred occasionally in cultures exposed to high temperature for only 6 hours. The disease was also controlled by subjecting artificially and naturally infested soil to heat generated by the normal fermentation of manure in a commercial mushroom house.

603. Snapdragons infected with rust were placed in houses where the night temperatures were 40°F.-45°F., 50°F.-55°F. and 60°F.-65°F., adapted to the culture of sweet peas, carnations and roses, respectively. The carnation temperatures were favourable for the growth of snapdragons, but rust was prevalent on susceptible varieties. In the cooler house the plants were free from rust, but grew very slowly. At 60°F.-65°F., the plants were free from rust, and although the stems were not quite so heavy as at the cooler temperatures growth was satisfactory.

604.* In low-temperature studies, under-cooling and freezing-point determinations provide valuable data. The piercing method of making the determinations produces shock to the organism and gives inaccurate readings of temperature. A means of making determinations by contact is described and detailed instructions for the construction of a contact thermocouple are given.

605. A general account of temperature conditions within the bee-hive with evidences that these changes have a marked effect on the physiological activities of members of the colony. The effect of outer temperature on flight and walking of bees is also discussed.

606. Experiments were conducted in the Province of Manitoba, Canada, lying North of 49°Lat. In summer the temperature occasionally goes above 90°F. and the nights are comparatively cool. The more hours of sunshine, the more nectar the bees bring to the hive. The greater the difference between night and day temperature, the greater the increase in weight of the hive.

607. Experiments at Tomsk, Siberia, where winter temperatures are exceedingly low, showed that the critical temperature for Anopheles maculipennis, Mg., is about -40°C. For Culex pipiens, L., it is much higher, being about -17°C. to -18°C. Shcherbakov's experiment on the effect of low temperatures on A. maculipennis was repeated, and it was found that at an average temperature of -18°C. with an average minimum of -23°C. the females can live for weeks or even months; 2½ per cent. survived for nearly fifty days at an average of -18°C. and a minimum of -36°C. Three were given blood-meals in May, and one oviposited.

608. Eggs were incubated with Huxley's apparatus devised for subjecting chick eggs to a temperature gradient. The cold tubes of the apparatus were set at 20°C-25°C. and the hot tubes at 46°C-47°C., which gave a difference within the egg of perhaps never more than 5°C. Of 184 eggs subjected to different temperature gradients (adjuvant, antagonistic, or lateral) for varying lengths of time, some were opened immediately and some submitted to normal incubation. The 35 eggs, which showed some definite effect of the gradient, exhibit a distinct alteration of the proportion of various parts of the embryo and blastoderm, indicating a disturbance of relative growth rates. Such alteration involved the area vasculosa (greatly extended on heated side) flexure and torsion of the embryo, the primitive streak, heart, limb-buds, optic, vesicle neural tube (thicker on cooled side), somites and spinal ganglia (displaced forward on heated side). There is some evidence of considerable power to regulate to normal when the treatment is followed by normal incubation.

609. Observations are reported which showed that the temperature of the surface soil was lower under wheat than under bare fallow. The temperature of the air immediately above the soil was influenced by the plant cover, but in varying degree, depending upon the time of day, wind and other factors. The plant cover increased the moisture of the air.

610. It has been found that with an outside temperature in the neighbourhood of freezing a hotbed will require approximately 1 kw. per hour of electricity per 24 hr. per sq. metre of soil for the average run of hotbed crops. The night use of electricity for this purpose has been found to vary from 100 to 150 watts per hr. per sq. metre of soil.

611. Cultivation of the surface of the soil in California did not affect the retention or distribution of moisture in the soil. In comparison with the loss of water by plants through transpiration, the amounts lost by evaporation were relatively small. Losses by evaporation from the soil were confined almost entirely to the upper 8 in. Movement of moisture from a moist soil mass to a drier soil mass was found to be much slower in rate and less in extent than usually supposed. It was found to be impossible to bring about a relatively low moisture content, uniformly distributed in the soil, by application of water on the surface or at any point within the soil mass. The rate of loss of moisture per unit area of leaf surface was independent of the soil-moisture content until the latter was reduced close to the wilting coefficient. Length growth of young prune trees in containers was also independent of the amount of soil moisture available for growth. No noticeable differences in width of stomatal openings of mature fruit trees were observed so long as available moisture was present in the soil, but marked response was found when the available moisture in the root zone was almost exhausted. The time of leaf fall and maturity of shoots of peach trees was not affected by heavy applications of water late in the growing season. Trees irrigated late in the season were not injured by temperature ordinarily experienced in California during the winter season.

612. Studies on the movement of soil moisture and its availability to plants have been largely experimental and there is need of a comprehensive guiding theory. The energy potentials and dynamical methods which have been found so useful in studying electricity and heat may be equally well employed in soil-moisture investigations.

A discussion is given on the nature and use of potential functions, and the electrostatic, gravitational, pressure, capillary and total potentials are defined.

It is shown that, when the proper units are used, the value of the capillary potential in soil which is in moisture equilibrium with water through a porous clay wall is numerically equal to the difference in pressure in the water and atmospheric pressure. The capillary potential is therefore a measure of the pressure in the soil solution.

The factors determining the capillary potential in a moist soil are discussed and experimental data are given which show the relation between this function and the percentage of moisture for four different soils.

The

The flow of moisture through soil can be expressed as simply the capillary conductivity times the potential gradient, i.e. $v = -k$ grad. (This is analogous to Ohm's law for electricity and Fourier's law for heat.

Application of the potential theory to soil-moisture movement is made for the following cases: (1) Flow of moisture downward through soil after rainfall or irrigation, (2) flow of moisture upward from a saturated water table, and (3) movement of moisture in a horizontal direction.

The availability of soil water to plants involves two factors, viz, the "security" with which the water is held by the soil and the readiness with which moisture flows in to replace that which has been used by the plant. The capillary potential is a direct measure of this "security" factor. The rate of moisture flow toward the roots is quantitatively expressed in terms of the transmission constant and potential gradient by the above equation.

A new form of porous clay apparatus is described which can be used in controlling soil water for potted plants.

The capillary potential offers a means of quantatively expressing soil-moisture phenomena and has advantages over the commonly used methods of designating soil-moisture condition as a factor in plant environment.

613. In extensive experiments extending over a period of years, the authors have observed a remarkable constancy of the residual moisture content for a given soil when permanent wilting is attained under widely varying conditions as regards evaporation, the trials indicated seeming to support the view that on a given soil all plants reduce the moisture content of the soil to about the same extent up to the attainment of permanent wilting. In an earlier report they showed that with some soils remarkable agreement existed between the observed and the calculated wilting coefficient. However, later results with many soils are said not to have upheld the supposed correctness of the ratio (wilting coefficient= moisture equivalent: I.84), and they do not believe that a common factor for all soils may be used to calculate the amount of water which remains in the soil at permanent wilting.

An account, with tabular data, is given of experimentation in which sunflower plants were grown in containers of two sizes under the varied seasonal conditions prevailing at Davis, Calif. From the data, though these show close agreement with the 1.84 ratio, it is concluded that the amount of water available for plant growth cannot be determined from the moisture equivalent alone. The authors think that the moisture equivalent is the best single-value determination of interpreting the moisture properties of soils, but that it is not an exact measure of how much of that water is available to growing plants. "For accurate work it is evident that the amount of readily available moisture can be obtained only when the amount of residual

moisture

moisture at permanent wilting is known, because it seems that plants are able to reduce the moisture content of different soils to different degrees of dryness before this stage of wilting is reached.

614. From experiments with Helianthus annuus, Polygonum fagopyrum and Vician Faba, it is evident that plants which have developed in conditions of insufficient water supply are marked in anatomical and physiological respects by their adaptation to the life conditions which have been offered to them. These plants wilt at the onset of the drought and are able in this conditions, without considerable loss of dry matter, to survive undamaged. A sudden diminishing of transpiration - and probably a certain stability of protoplasm in the wilted condition - is the cause. So soon as a sufficient water supply becomes available the "hardened" plants transpire and assimilate after their extraordinarily intensive rest. Thanks to their capacity to utilise better the periods of sufficient water supply, plants can, as a result of the losses caused by wilting, again become wet as they collect per unit of leaf surface almost as much dry matter as the watered plants in the control experiment. For the practical man, it is a question, therefore, of having regard, not only to the predisposition of a plant, but also to the possibility of its "hardening" through corresponding conditions of development.

615. Studies in the Yale Demonstration and Research Forest near Keene, N.H., in the summers of 1925 and 1926 showed that in this dominantly white pine region there is considerably more moisture present in the upper soil layers than in the lower, both in the open and in the forest. Soil moisture decreased consistently with increased depth down to at least 100 cm. The decline was rapid down to about 40 cm., below which the changes became more gradual. Soils in the open contained considerably more moisture during dry periods than did forest soils, with the differences greatest in the upper layers. Open soils were considerably denser than forest soils, and when based upon weight the latter had a much higher water-holding capacity.

Concerning wilting coefficients there was noted but little difference between the open and the forest soils. However, due to the concentration of organic and colloidal matter in the upper layers wilting coefficients were higher than in the lower layers. The maximum volume of available water that the soil could hold was 5 per cent. greater in the forest than in the open, but forest soils because of their porous nature permitted seepage at a rate almost three times that occurring in the open.

Observations upon soil moisture in trenched and untrenched quadrates established beneath a canopy of white pines showed much more available moisture in the trenched areas from which roots of surrounding trees were cut off. In both the trenched and untrenched quadrates there was usually more moisture available in the upper than in the lower layers.

During

During summer drought the available soil moisture sometimes declined below that essential to support life in the lesser vegetation, thus accounting in part for the lack of ground flora under pine canopies. In spring and autumn when soil moisture was abundant the differences between the trenched and untrenched quadrates were slight.

616. The importance of sunlight, both directly in stimulating sturdy growth and indirectly in increasing the temperature of the soil in the cool upper altitudinal ranges of the southwest, was indicated in studies conducted by the U.S.D.A. Southwestern Forest Experiment Station of Flagstaff, Ariz. The average temperature for the five months, May through September, at a 12-inch depth for soil in full sunlight, 25 per cent. shade, and 60 per cent. shade was, respectively, 63.0°F, 56.4°F, and 54.7°F. Where the air temperature was too low for the best growth the author believes that the heat deficit may be made up by direct insolation. Furthermore, in very low light intensities but with adequate moisture it was observed that species tended to assume a slender, weak form.

Soil moisture is conceded to be the critical factor in the early life of forest seedlings, but after the roots have penetrated to a foot or more lack of moisture was manifested in slow growth rather than death. As shown in earlier experiments by the author potted conifers of several species were found capable of surviving in a nearly dormant condition when the wilting point was approached. In the present study where competition of tree roots was relieved by trenching, trees in partial shade made but poor growth or succumbed, while those of the same age classes in near-by open spots made substantial growth.

617. From among a large variety of observations on Amarillo silty clay loam during the crop season 1924-27 and conclusions recorded the following may be cited:

From 22 per cent. to 39 per cent. of the total rainfall of a wet period might go into the subsoil, and in the heavy type of plains soil investigated about 20 per cent. of the annual rainfall became subsoil moisture. Showers in which the precipitation amounted to 0.5 in. or less did not increase the soil moisture unless these light rains fell during consecutive days; and the rains exceeding 1 in. occasioned some run-off unless they fell very slowly or were held on the field by contour tillage or by level terraces. Run-off from heavy soils of "minimum slope" was estimated at 13.5 per cent. of the total rainfall.

About 20.7 per cent. of the total rainfall was found to become soil moisture. Of this, some 2.7 per cent. was lost in the evaporation occasioned by ordinary tillage operations, leaving 18 per cent. available to plants. About 65.8 per cent. of the total rainfall was found to evaporate from the surface either during the precipitation or immediately thereafter; and out of the portion so lost 31.3 per cent. is considered to have been contributed by showers individually

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too light to add anything to the "permanent store" of soil moisture. The fractions of the rainfall which were found so light or so heavy as to add nothing to the soil moisture did, none the less, aid materially in crop growth.

Under the conditions of the cropping experiments, the average growing season having been 114 days, an average of 0.91 in. of water is addition to the current rainfall was taken from the soil by the crop. With respect to crop yield, the initial soil moisture content was found to have an effect approximately equal to that of the quantity of the current rainfall.

Only such cultural conditions as remove moisture very rapidly, deep ploughing, for example, or plant growth, were found to threaten the immediate loss of a body of stored moisture. The temperature appeared to have an effect relatively unimportant with respect to the quantity of moisture stored or to the rate of gain of moisture in the soil, but was highly significant, in modifying the relationships of rainfall, wind, and humidity to the behaviour of soil moisture.

618. Water given to wheat after earing, though not having the importance of that given it during the preceding period, maintains a certain influence on the yield of grain; it does not conduce to the formation of new organs. With oats, the giving of additional water after earing leads to the development of a new generation of feeble or sterile shoots and tends to diminish the quality of the grain.

619. Rain is recorded over a forested area while adjacent cultivated fields received none, thought to be due to the cooling of moisture-laden air passing over the forest.

620. The quantities of dew placed each year directly or indirectly at the disposal of plants are, in Central Europe much greater than those indicated by drosometric measures. Dew can, by the aid of suitable cultural methods, exercise a favourable influence on the maintenance of water in the soil. Plants absorb the water (the dew) by means of those organs which are above ground in quantities varying with their nature. In certain cases and with the majority of plant species, this absorption which takes place above ground can be in direct relation to the total consumption of water. Water absorbed by the organs which are above ground has a different physiological action on plants from that which is brought to them by means of their roots. The latter in reality is not pure water, but a solution more or less rich in salts, Dew brings to the leaves water free from salts which exercises a diluting or delaying action which balances the excessive concentrations of saline solutions as brought by the roots. This balancing process is absolutely necessary for the health of numerous plants. By means of an artificial supply

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of dew it has been possible in pot experiments to sensibly increase the yield of oats and mustard even when the latter was cultivated in water. The content in ash as a percentage of the dry matter is, in the case of plants subjected to the action of the dew, lower than in the case of plants not subjected to dew. With regard to organic matter on the contrary the results are reversed. Plants sensitive to salts are more influenced by their absorption of water above ground thanplants insensitive. The saline sensitiveness of plants varies according to the degree of their development or according to their habitat. The results of research show that the absorption of water from the atmosphere by plants which are found in dry countries or which are dried by the winds, plays a less important part than in the case of plants growing in places normally humid. In the same way, the capacity for the absorption of water by the leaves appears to be different. The natural supply of water through the leaf cannot always be replaced by that from the soil. In the case of sensitive plants, sufficient soil humidity cannot counterbalance the harmful influence of the lack of dew caused by the dry atmosphere. The wind plays a part in absorbing dew and perhaps in consequence, greatly hinders its formation. Distance from forests, protection against wind can in certain cases modify to a greater or less degree the ecological conditions of a district so far as the quantity of dew is concerned. It should be observed that the difficulties in the way of reafforestation in numerous deforested lands is due in part to these causes.

621. Premature tuber formation in early potatoes (blind tubers, "submarines") is induced by certain undesirable storage conditions (especially high temperature and darkness) which induce a rapid sprout formation, so that sprouts must be removed several times during storage. Atmospheric humidity proved to be of minor importance. The sprout-formation is about the same under dry and under humid conditions; at the end of the storage period the "humid" tubers form more, but thinner, sprouts. Evaporation is condiderably higher under dry conditions. Contrary to Oortwijn Botjes, whose experiments are criticized, the final conclusion is that no special attention need be given to control of atmospheric humidity, but that low temperature and light are the essential factors.

622. The effect of relative humidity on the dissemination of malaria is discussed from the literature. It has been shown that whereas humidity exercises no direct effect on the malaria Plasmodium in the mosquito, and although infected and uninfected mosquitoes react in the same manner to atmospheric states, the temperature and humidity conditions compatible with the transmission of malaria are confined to a more restricted range than those favourable to the bionomics of the insect vector.

The following is taken from the author's summary of the results of experiments carried out to determine the minimum effective range humidities permitting both life in the mosquito and viability of the imbibed malaria. In the case of Culex fatigans, ied, and the organisms of bird malaria

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the minimum effective range was observed to be 44 per cent. to 46 per cent. in two batches of mosquitoes maintained at temperatures up to 72°F. and at temperatures above 80°F. At relative humidities under 42 per cent. and dry bulb temperatures of 73°F. or under, out of a total of 195 mosquitoes tested, only 4 were induced to bite, and these became infected. At temperatures above 80°F. at similar relative humidities, none of 128 survived more than 4 days nor became infected. At these temperatures and 43 per cent. humidity, 2 mosquitoes survived 3 days, showing incipient parasite development.

In similar tests with Anophelines at temperatures under 67°F. and relative humidities from 38 per cent. to 55 per cent. Anopheles culicifacies, Giles, and A. subpictus, Grassi, failed to survive one week, whereas more than 200 specimens of A. fuliginosis, Giles, survived fully 17 days at a minimum relative humidity of 38 per cent. At temperatures above 80°F. those 3 species failed to resist a desiccating atmosphere of 40 per cent. to 42 per cent. for more than 24 hr. At relative humidities of from 55 per cent. upwards and temperatures above 80°F., and at relative humidities above 57 per cent. and temperatures below 67°F., all 3 species survived from 1 week to 4 weeks.

The experiments on the effect of relative humidity on the development of malaria parasites (Plasmodium vivax) in A subpictus and A. stephensi, List., resulted in the survival and infection of 2 of the former during 1 day to 3 days, at 39 per cent. to 42 per cent. humidity and 4 during 6 days to 13 days at 54 per cent. to 59 per cent., the temperature being 84°F-86°F and 88°F-90°F. In the second test development inthe mosquitoes was carried to the sporocoite stage. Three out of six individuals of A. stephensi that succeeded in biting a patient demonstrated various stages of plasmodial infection during a course of 5 days to 11 days of 80 per cent. to 88 per cent. humidity and 85.5°F. Only one showed a few gland sporozoites.

In these tests, a definite result was obtained indicating a species adaptation to relative humidity. This consisted of an effective range of humidity allowing for an infective period in the mosquito at an optimum temperature for functioning. The following range of minimum relative humidity was established: A. fuliginosus, 38-40, C. fatigans, 43-45, A. subpictus and A. stephensi, 55-58 and A. culicifacies, 57-62. It was determined that, during an aestivating period involving a relative humidity of 44 per cent. to 50 per cent., infected mosquitoes (C. fatigans) survived for periods up to more than three weeks (24 days). These had been maintained at normal high humidities for 10 days previously. Of these, 78 per cent. retained their parasites during the period of enforced drought, contrasted with 72 per cent. of control individuals, which remained infected through the 34 days of experiment.

The relation of relative humidity to the stimulus of seeking blood in C. fatigans was tested. The results indicate that biting does not occur at relative humidities under 52 per cent. even in the presence of high dry bulb temperatures. This demonstrates that this mosquito cannot be induced to bite in an atmosphere of relative humidity in which it is unable to survive desiccation.

623. A trap in which light was the attrahent for night-flying insects was divided into 8 similar compartments and, by means of a wind vane, arranged so that each compartment kept a constant relation to the direction of any wind that might be blowing. Counts of about 10,000 captured insects showed that 27 per cent. (instead of the 12.5 per cent. expected on the basis of random approach) entered the trap by going against the wind and only 6.6 per cent. entered with the wind.

624. Studies were made upon the effect of various intensities of light upon the utilisation of the reserve foods in carefully selected seed of pure lines of barley and wheat. The seedlings were grown in glass cylinders supported on paraffined muslin. Different intensities of light were obtained by wrapping the cylinders with 1, 2 or 4 layers of paper. The weights of the embryos and the remainder of the seed were determined. The free reducing sugars and sugars after inversion were determined in the roots, stems and leaves, and in the remainder of the grain. To learn the possible effects due to photosynthesis, some lots of plants were grown in ordinary air and others in a stream of air from which CO_2 had been removed. The weight of the young plant was less in darkness and in full illumination than when the light intensity was reduced. The sugar content of the remaining portion of the seed was highest in the seedlings grown in darkness and lowest in those grown in the cylinders wrapped with 2 thicknesses of paper. Light, therefore, produces a direct action upon the processes of oxidation of reserve substances and their synthesis into living protoplasm.

625. Increases in the sap concentration of leaves of Eureka lemon and Valencia orange occur when the leaves are exposed to direct sunlight. The sap of the Lemon leaves on exposure to direct sunlight increases its concentration more rapidly than does that of the orange leaves. Increases in sap concentration due to action of sunlight on the leaves are due entirely to photosynthetic products, the ash of the sap remaining the same under both conditions. A greater percentage of the cross-sectional diameter of the lemon leaves is occupied by palisade tissue than with the orange leaves. This, together with the fact that more Mg. is found in the sap of the lemon leaves than in that of the orange leaves, and the more rapid response of leafy lemon cuttings to negetative propagation, lends support to the view that greater increases in lemon leaf sap concentration in direct sunlight over that of orange leaf sap may be due to a more efficient photosynthetic system. The great variation in sap concentration of citrus leaves brought about by direct sunlight indicates that large errors may result through indiscriminate sampling.

626. In rice breeding it is often impossible to cross 2 strains when they differ markedly in their flowering time. Plants of the variety "Aikoku" were exposed in July, (1) to daylight 5 hr. to 9 hr. per day, (2) to normal

daylight

daylight condition, and (3) to daylight and electric light at night. The 1st group of plants begin to flower 1 month earlier (end of July) than the 2nd group (end of August), while the 3rd group showed no sign of flowering even as late as 15th October. Thus the rice plant is a short-day plant in Garner and Allard's sense, and we may profit by this in crossing 2 strains which differ considerably in their flowering times.

627. By growing seedlings of 12 species on a 7-ft. revolving table carrying about a ton of soil and abundantly supplied with moisture, it was sought to determine whether there are important differences in the minimum light requirements. Samples of each species were taken after a germination period of 60 days in sunlight, and their dry weight determined. Thereafter the only light supplied was that from a 200 watt tungsten-filament blue-gall lamp, suspended 12 in. over the centre of the table. Measurements were made with a thermopile to determine the intensity of light received at various distances from the centre of the table, these decreasing from 13 per cent. to 0.7 per cent. of full noon sunlight. At the end of 9 months all surviving seedlings were taken up, and their dry weight determined. Both growth and survival percentage were considered in attempting to fix an end-point expressing the capacity of the average seedling of a species to use weak light. From 588 seedlings living at the end of the test it is concluded that Sequoia sempervirens can make appreciable growth with light of 0.62 per cent. intensity, Picea engelmanni and Pseudotsuga taxifolia with 1.1 per cent. and 1.3 per cent. respectively, 7 species and forms of Pinus with 1.8 per cent. to 2.7 per cent, and Pinus edulis with 6.3 per cent. That such low light intensities are often, at least, not tolerated in nature, is due to the introduction of another factor. Meagre development is clearly reflected in weak roots which affect the ability of the seedling to withstand drought or competition. The absolute light requirements indicated are in accord with the relative productive capacities of the several species.

628. Wheat and barley are long-day plants. When forms of wheat (T. vulgare var. erythrospermum Körn.) and barley (H. coelestis pamiricum Vav. H. trifurcatum Schlecht, H. nutans f. chevalieri R. Regel, and H. lapponicum R. Regel) differing sharply as to the latitude of their origin were subjected to different day-lengths in pot cultures, a definite relation existed between the reaction of a given form to length of day and its origin. Southern forms accustomed to growing in a relatively short day are less seriously affected by a reduced day-length with respect to initiation of the reproduction stage and yield of grain than are forms of northern origin. In the forms of wheat and barley, the retarded reproductive development resulting from exposure to a short day was accompanied by excessive vegetative development, as manifested by increased production of total dry matter and

greater

greater development of leaf surface, the latter in some cases amounting to 9 times to 10 times that of the controls. In preliminary tests with several forms of flax (Linum usitatissimum), which behaved as long-day plants, some of these forms exhibited a similar relationship between their photoperiodic behaviour and latitude of origin while others did not; 2 forms of southern origin were quite sensitive to a short day. The influence of the short day on the morphology of flax manifested itself mainly in increased basal branching, while production of dry matter and development of leaf surface were reduced. In wheat, barley and flax, decrease in length of day to a certain point resulted in reduction in size of cells, a reduction in size and increase in number of stomata, and increased development of veins per unit of surface area. Further shortening of the day reversed these relations. The limits in length of day thus influencing the characters mentioned varied with the different forms, depending on their individual characteristics. In flax, exposure to decreased length of day resulted in a decrease in the thickness of stem and in the development of its xylem and phloem, while the diameter of the pith was increased.

629 *(1) The fact of the influence of geographical conditions on photoperiodism, established in the preceding work for some barley forms has been verified on a series of other forms of the same crop. The fact of greater tolerance as regards a short day, shown by the southern forms as the result of the influence of the natural habitat conditions, has been wholly confirmed.

(2) The investigation of a great number of geographical forms of durum wheats, Tr. durum var. melanopus and Tr. durum var. hordeiforme, differing in their latitudinal origin from 45° to 58°, has established the direct connection between photoperiodism and regions of origin. Under the influence of the shorter day, peculiar to the region of their natural habitat, the southern forms are less exacting with regard to the duration of the day and fructification is less delayed in them by a short day than in Northern forms. With a 12 hour day, earing is retarded in a southern (Abyssinian) form by 17 days, in a northern (Krassny Kut) one by 46 days.

(3) The investigation of 12 varieties of oats has established that the whole crop belongs to the plants of a long day. The influence of the regions of origin is very marked in this crop. The southern forms lower their requirements with regard to the duration of the day so much that with a 12-hour day the rate of development hardly differs from that of the controls. They were behind the latter only by three days, while the northern forms scarcely had time to throw up their panicles by harvest time.

(4) The experiments with rye have equally established that the crop belongs to the "long-day" plants and that there exists a definite dependence between the geographical origin of a given form and the limits of its

tolerance

tolerance with regard to a short day. The southern forms are markedly less exacting as to the duration of the day. With a 9-hour day, Afghan rye is delayed in its shooting stage by 22 days, with a 12-hour day by 13 days; Yakutian rye is delayed in the first case by 40 days, in the second case by 22 days.

(5.) The deep physiological difference existing between Miliaceae and the other cereals, shows itself equally in regard to photoperiodism. In opposition to the other cereals, and similar to maize and sorghum, millet is a sharply marked "short-day" plant. The great sensitiveness of millet to the duration of the day makes this plant an excellent subject for the study of the physiology of photoperiodism. In millet the connection of photoperiodism with the geographical origin does not show so simple relations as in the other above-mentioned crops and does not afford so clear a picture.

(6.) The study of different varieties of peas has shown that this crop belongs to the plants of a long day, but that the degree of responsiveness in this regard is very different in the different varieties. While some varieties (Pamir and Afghan ones) are so far exacting to the length of the day that with a 12-hour day they do not even reach the reproductive stage, other varieties (Italian, Abyssinian ones) retard their flowering only by several days. Finally, the northern pea of Pissarev shows a neutral reaction with regard to the length of the day. As is easily seen, the connection between photoperiodism and the geographical factor shows in peas an opposite character to that established for cereals. Thus, among the forms of peas, studied by us, the Southern ones have proved more exacting as regards the duration of daylight and suffer more from a short day. However, in view of the limited number of forms studied by us, the above-mentioned dependence cannot be recognised as general for the whole crop.

(7.) The response of the different forms of beans with regard to photoperiodism is not homotypical and the character of this response depends on the region of origin. The influence of the natural habitat conditions on the photoperiodism of the given form is so strong, that it shows itself not only in the degree of response but induces even changes in the sign of this response. The southern forms acquire the peculiarities of "short-day" plants, and the northern ones acquire the peculiarities of long-day plants.

(8.) The observations conducted by us with regard to the photoperiodism of horse beans, lentils, chickpeas, show that these crops belong to the plants of a long day. The connection between photoperiodism and geographical origin may be indicated, but in view of the insufficient number of forms investigated, must not be regarded as established.

630.* The work was carried out in the physiological laboratory at Detskoje Selo near Leningrad during the summer seasons 1927 and 1928 under the guidance of Prof. N.A. Maximov. The influence of a varying day-length on the time of flowering of different crop plants was investigated. The scheme of the experiment included two control groups which obtained only long or short days during the whole vegetative period, and two groups which obtained a day of varying length; namely the first developed in the beginning at a short day (10-12 light hours) and obtained a long day later, the second underwent the reverse treatment, a long day in the beginning of the vegetation and a short day later.

The experiment was planned for the purposes of (1) determining the influence of a varying day-length upon the time of flowering, literature data concerning this question being very scanty: (2) attempting, on the basis of the results obtained, an analysis of the differences in the yield and general character of the development of plants which may be observed in natural conditions in connection with the different time of sowing, profiting for this purpose by the available literature data.

The following long and short-day plants served as material for the investigation: panicum miliaceum - Tulun; Avena sativa var. mutica - Finland; Avena abyssinica; Hordeum pallidum - Archangel; Raphanus sativus - Japan; Solanum demissum - Mexico. For shortening the day the experimental plants were driven on cars into a dark house specially adapted for the experiments.

The following conclusions may be drawn from the results of the experiments:

(1) the length of day to which the plant is exposed in the very first days of its life leaves a deep imprint on all its further development and especially on the time of the change from the vegetative stage into the reproductive stage. Short-day plants, that have been exposed to several short days in the beginning of their development, perceptibly hasten flowering, several long days on the contrary delay the reproductive stage. Long-day plants show the reverse reaction. We name this phenomenon "photoperiodical after-effect".

(2) If exposure to a long day causes flowering at a greatly differing time from exposure to a short day, it is possible in combining different numbers of long and short days to obtain the flowering stage at almost any moment between the two extremes. A comparatively small number of days of a definite length may considerably advance or delay the time of flowering of a plant. Thus we have in the photoperiodical after-effect a mighty expedient for regulating the length of the vegetative period of plants.

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For the manifestation of the photoperiodical after-effect a certain minimum number of days is necessary otherwise this influence of the conditions of the first stage of development will be completely suppressed by the action of the consequent light regime.

(3) The photoperiodical after-effect of a short day has a stronger effect on short-day plants; long-day plants are more strongly affected by a previous long day.

This statement is correct for days to which plants have been exposed in the first stages of development, as well as for those to which the plants have been exposed in later periods, after they have already been subjected to a definite light regime.

(4) Some plants manifest the after-effect strongly (millet), others weakly depending on their sensibility to changes of day length.

(5) A shorter day (10 hr.) shows a greater photoperiodical after-effect than a less shortened one (12 hr.) although this process continued only to a certain limit of the shortening of the day length.

(6) The influence of the initial light regime on the further vegetative development of the plants is quite definite for plants of a long day as well as for short-day plants. For most of the plants investigated (millet, oats) the after-effect upon the vegetative development must be regarded as a secondary phenomenon, depending chiefly on the reproductive stage; for one form of southern oats the after-effect upon the vegetative development represents evidently an independent process, not depending upon the reproductive development.

(7) It is a firmly established fact that later sowings of some spring forms of oats, barley, wheat and other plants decrease considerably the period between germination and heading, simultaneously lowering the yield, while other plants, as for instance millet, give a better yield when sown later. This may find an explanation in the phenomenon of the photoperiodical after-effect, considering the increase of the day length in passing from the early-dated spring sowings to the late summer ones, and on the other hand, in the opposite reaction to the day-length of these two groups of plants.

(8) The physiological nature of the photoperiodical after-effect, as well as of the phenomenon of photoperiodism in general remains undetermined. In any case it is combined with some internal physiological processes, beginning in the plant from its very first days of development and displaying its influence in the time of flowering some time after the factor exerting this influence has been removed and even substituted by a factor of the opposite influence.

631.* The aim of the present work was to study in detail the influence of the length of day on the tuber

set

set in potatoes and several other tuber plants. In order to demonstrate more strikingly the influence of the factor mentioned, besides forms producing tubers easily, such species were taken for the experiments which in our conditions possess either a low capacity for tuber development, or which are completely devoid of this capacity. The work was carried out at the Physiological Laboratory, of Prof. N.A. Maximov at the Institute of Applied Botany and New Cultures in Detskoe selo near Leningrad.

The results of the work lead to the following conclusions:-

(1) The length of the day is one of the main factors determining the process of tuber set. An unsuitable length of day may not only change the degree of tuber-production, but it can completely suppress this process, and the reverse - an optimum day-length may stimulate the tuber set in forms which in our conditions are devoid of the capacity of tuber formation. A long day suppresses the tuber set, a short day stimulates it. The optimum day-length for tuber set is a shortened one, in some cases 9 hr. in others 12 hr. to 13 hr.

(2) The suppressing influence of a long day on the tuber set has been studied on a series of potato varieties (Lowtop Burbank, Violet Moyse, Dojeck local variety, Burstenkrone, Spaulding Rose, Cornwallis, South American native variety and Solanum palustre Poepp.) It proved that a short day increased in all the varieties investigated the yield of tubers, as well as their number. The productivity of the tuber set is highest with a 12-hour day. The ratio between the green weight of the tubers and the tops increases from the control to the short day plants from 0.4 to 2.0. The comparison of these organs in an air-dry state gives a still greater amplitude in the ratios. The process of tuber set of different potato varieties shows a specific dependence on the length of day. Thus while the first 6 of the varieties mentioned are capable of setting tubers with a short as well as with a long day, the short day only increasing the production, other varieties (South American native, Solanum palustre Poepp., Solanum demissum Lindl.) are so specific, that they can form tubers only at a definite length of day (12-9 hr.) and an increase beyond these limits deprives them completely of the capacity of setting tubers, that is in these conditions they are transformed into plants not carrying any tubers. The cultivation of these plants with a short day represents an indispensable condition for tuber set.

(3) In regard to the influence of the length of day on the beginning of flowering, all the forms of potatoes that we have investigated do not show the same reaction. The difference in the photoperiodism of the potato varieties studied is probably connected with the wide area of origin of this culture. Most of the forms investigated belong to long-day plants which must be related to the origin of the main bulk of potato varieties, from the lowerlatitudes of the southern hemisphere, from regions characterised by a long day.

(4) The suppression of the tuber set by a long day noted above has also been established for a series of forms of Ullucus and Oxalis and with these species the reaction is still more sharply expressed than with potatoes. The optimum day length for the tuber set of the forms mentioned is 9 hr. With a 12-hour day, though the tuber set takes place, it is considerably delayed and the yield of tubers is very low. A long day suppresses the natural capacity of these forms to set tubers thus transforming them in our conditions into plants not carrying tubers. The optimum day-length for the vegetative development is the 13-hour day, the 9 hour day stimulating the tuber set but suppressing to a considerable degree the vegetative development.

632.* Photoperiodic experiments were carried out at the Institute of Applied Botany and New Cultures in Detskoye Selo near Leningrad, with seedlings of Robina pseudoacacia L., Phellodendron amorenso Rupr. and with cuttings of Salix Lanata L. and Salix babylonica L. The observations of the first year allow the following conclusions to be drawn:

(1). The trees and shrubs experimented with change the length of the phases of their phenology and growth energy in accordance with the length of the day during their vegetative period. In conditions of a long day the length of the phenologic phases increases and the yearly growth is greater. On the contrary, in conditions of a short day the phases are shorter, the vegetative period is decreased and growth is less.

(2). The following main differences could be observed in the response to a short 10-hour day of R. pseudoacacia - a representative of lower subtropic latitudes and consequently of a shorter day, and S. lanata - a representative of high latitudes and a long day:

While the short-day plants of the polar willow terminated their growth period early, in July, the control plants stopped growth only in September, though long before winter set in. The short-day plants showed a considerably greater intensity of growth from the very beginning of the experiment; at the end of their growth period in July they surpassed the control plants in size almost twofold. However, thanks to their longer growth period the controls finally surpassed the experimental plants by 1½ times.

The locust responded differently to a short day. The control plants exhibited a high growth intensity and did not stop growth until the branches were killed by the first frost. The short-day plants, on the contrary, decreased their growth rate as soon as the experiment was begun. Thus two woody plants respond inversely to a short day: one increasing, the other decreasing its growth-rate.

(3). One of the main factors determining the limits of spread to the North of woody plants, namely frost resistence, depends to a considerable degree on the response of the given plants to the length of the day. It is evident that such species as the locust will not stop their growth and ripen in conditions of a long day and consequently will be killed by frost. In selecting frost resistant plants it is first of all necessary to choose those plants which terminate their vegetation in conditions of a full day-length characteristic of the given habitat.

(4). Information found in dendrologies and encyclopedias respecting the growth rate of different species must be acknowledged as of a very relative value. One and the same species may be characterized as either rapidly or slowly growing according to the length of day.

(5). The length of day does not only affect the energy of growth and the length of vegetative phases, it also causes morphological changes in the woody species. The short-day seedlings of the locust differed sharply from the controls: they did not branch as the control plants. While the control plants had many well-developed thorns the short-day plants had none or only weakly-developed ones in the shape of small scales. The leaves of the controls were formed by a large number of pairs of ellipsiod leaflets and were of a greenish-yellow colour, while the leaves of the short-day plants had a reduced number of pairs of leaflets. The leaves were of a more rounded shape, skinny and of a dark green colour. The young leaves and shoots of the control plants were rich in anthocyan, while the experimental plants were devoid of it.

(6). The length of day affects the development of the root system of the locust. There is a considerable increase of the relative weight of the roots in short-day plants. The general shape of the thickening of the main root changes as a consequence of a large accumulation of starch in the roots.

(7). The large accumulation of starch in the roots and stems of the short-day seedlings makes one suppose that they will begin their reproductive activity much earlier than the controls. Such an early maturity and rapid succession of generations in woody species is one of the chief conditions of the productivity of genetical study and rapid selection and establishment of the more valuable biological properties. This is why the method of photoperiodism is of great value in the study and breeding of woody species.

633. Cucumis, Ipomea, Zea mays, Coleus, Lactuca, Raphanus, Bryophyllum, and Phaseolus plants were radiated with an air-cooled uviarc quartz-mercury lamp. The open arc and 2 light screens were used. All plants were treated 30 sec. the 1st day, which was increased the same

amount

amount each succeeding day. Direct rays were injurious in every case. Radiation with wave lengths above 289 produced larger plants. Leaf morphology is discussed with reference to ultra-violet stimulation. Stems radiated with the screened lamp became thicker and contained better developed vascular bundles than the controls. Radiating with the screened lamp generally increases the dry weight. The effect of radiation upon transpiration is also discussed. Results point to the supposition that each variety of plant has its own ultra-violet requirement for optimum growth.

634. Plants growing in the dark were subjected to the action of rays of a wave-length of 3300-3900 A.u. for 2 hr. to 8 hr. each day. Young wheat seedlings curve toward the light after 8 hr. of continuous illumination and the 2nd leaves develop enough chlorophyll to give a pallid green colour to the plant. With 2 hr. of exposure, the chlorophyll development was very slight. Bean seedlings developed chlorophyll after 7 hr. of exposure but the green chloroplasts showed no starch. While the rays used were much less intense than those of sunlight, they caused the formation of chlorophyll but not of starch.

635. During the summer of 1929 further experiments were carried out with electric light traps in an apple orchard in western New York. The traps used were similar to those already described, a clear glass 75 watt lamp being employed, and were suspended by means of screw-eyes from the lower limbs of the trees, 5 ft. to 6 ft. above the ground. One was hung from each of 105 trees on a 4-acre section of the orchard, the pans being filled with water alone.

The traps were operated from 15th June to 26th August, the lights being turned on about 8 o'clock at night and off shortly after 5 o'clock in the morning, and 27,726 adults of Eucosma ocellana, Schiff. (bud moth) and 16,432 of Tortrix (Archips) argyrospila, Wlk. (fruit-tree leaf-roller) were caught, besides numerous other insects, of which the more important are listed. E. ocellana was taken from 18th June onwards and T. argyrospila from 23rd June to 5th August, the maximum flight of both moths occurring on 7th July. Dipterous and Hymenopterous parasites were not numerous in the traps, only 1,895 individuals being captured during the season. In the case of Lepidoptera, flight was definitely inhibited when the temperature fell below 60°F. the moths being most active when it ranged between 65° and 70°F. The largest numbers of moths were caught in the outer rows of traps, a possible explanation being that the comparatively large unlighted area acted as a source of supply. Injury by E. ocellana to the leaf clusters was from 8 per cent. to 26 per cent. greater in the unlighted part of the orchard than in the lighted section, and from 2 to 7 times as many moths were present in unlighted trees. Males and females were caught in about equal numbers, and

few

few of the females had laid their eggs. The numbers of Cydia (Carpocapsa) pomonella, L. (codling moth) captured were very small, and observations indicated that infestation was low in all sections of the orchard.

Notes are given on the life-history of E. ocellana and T. argyrospila. The eggs of the latter are laid in June or July in masses on the twigs, branches and trunks of the apple trees. The larvae hatch in the following spring and feed on the opening buds. Later they web the young leaves together, sometimes including the young fruit, and after feeding for about a month, pupate, usually in the rolled leaves. The pupal period generally lasts about 10 days.

636. Under favourable conditions, larvae of Tenebrio obscurus, F. (Dark mealworm) hatching in the spring or early summer months become apparently fully grown by mid-August, but do not transform until the following spring. If, however, the larvae are kept in a heated room, some may pupate in November or December. Continuous exposure of the larvae to artificial light, from the latter part of August, considerably accelerated their development, five of them pupating within a month.

637. In a demonstration of all-night lights for layers, 3 groups of 40 Leghorn pullets each were started on 1st December. The groups averaged 19 per cent. egg production when the lights were turned on, 39 per cent, 2 weeks later, and 57 per cent. after 4 weeks of lighting. These birds laid 49 eggs each to 1st March and the mortality to 15th June was 12.5 per cent. Another lot with a 40 per cent. production before being lighted increased to 65 per cent. in 2 weeks and to 75 per cent. in 4 weeks. The pullets in this lot laid 57 eggs each from 1st December to 1st March, with a mortality of 12.5 per cent. In another test 24 January-hatched pullets, averaging 45 per cent. production, were moved from the range on 15th July. Loss of production and molt followed the moving. From 1st October until they received lights only 2 birds were laying, but 2 weeks after lights were turned on practically all birds were laying, and from this time to 1st April production averaged 63 per cent. with a mortality of 16 per cent. to 15th June.

638. It appears from numerous soil analyses carried out according to the method of Neubauer that the assimilation of P_2O_5 by plants is sensibly weaker during the summer months when light is intenser than during the winter months. On the contrary, the amount of K_2O which can be assimilated increases with the intensity of light. Further, the authors studied the influence of the composition of light. They did not observe definite differences between the effects of day light and those of its different constituents on the assimilation of P_2O_5. In all cases green light produced diminution of the assimilation of K_2O, whilst plants germinated under a blue or red light took sensibly more K_2O from the soil than those germinated in day light.

639. In view of the fact that workers on similar problems often find difficulty in obtaining duplicate or comparable results on account of the lack of adequate control of some environmental influence, the authors have attempted to develop an apparatus that would permit efficient environmental control without necessitating a large maintenance fund and that would at the same time meet the requirements for any desired expansion. It is stated that the resulting apparatus, though satisfactory, is not designed for extensive growth investigations where large numbers of plants are involved and where a soil culture medium is employed. A description is given of the apparatus permitting the growth of plants under controlled conditions of light, temperature, humidity and culture solution. This apparatus is constructed in units, making possible easy expansion with enlargement of research programme and budget. The data are said to show the feasibility of establishing an environment which can be duplicated at will. Such a controlled environment permits the isolation of a single variable and quantitative study of diverse physiological phenomena.

640. The outbreaks of Prodenia litura, F. (litteralis, Boisd.) on lucerne and cotton in Lower Egypt begin each year in early spring, and after several generations, the moth reaches its maximum numbers about the end of June and beginning of July. Between the end of July and early August, its numbers decrease very rapidly, although there is no increase in the percentage of parasitism. The beginning and end of the outbreak are determined entirely by temperature, since humidity varies little throughout the season, owing to irrigation.

Experiments under laboratory conditions on the influence of constant and varying temperatures on the rate of development of the various stages proved that development is not in a direct proportion to time, but can be regarded as a regularly retarded movement. Formulae and graphs indicating the rate of development as affected by temperature are presented on the basis of this concept. From the formulae it is possible to calculate the effect of even short exposures to the temperatures differing from the optimum on the subsequent course of development, and thus to evaluate the influence of such fluctuations of the temperature as occur in nature.

The author discusses the concept of critical thermal points for development of insects and concludes that such points do not exist in the biological sense and that development can continue, though it may be much retarded, at any temperature that is not injurious to the organism. The extreme temperatures, which are injurious, are of particular importance, since they control outbreaks of insects and determine the length of stages in their development. Average temperatures are, therefore, of very little value, since they do not reflect departures from optimum conditions.

Humidity and nutrition have the same general biological influence as temperature in that a variation from

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the optimum increases the length of development. The optimum relative humidity for Prodenia litura was found to be 90 per cent. to 95 per cent.

641. It was found that the temperatures of the alfalfa stems, leaf surfaces, and growing tips were very close to those of the surrounding air. The soil surface in alfalfa fields, when exposed to the sun, often reached from 50°C. to 60°C. unless the soil was quite moist. The mean daily temperatures of the air for the 10-hour periods at the 3.5-foot level averaged from 2°C. to 2.6°C. above those secured among the plants during May, June and July, while the mean daily temperatures for the 24-hour days were very similar at the different levels. The removal of a crop of hay was found to produce temperature changes near the ground which may be extremely disastrous to immature stages of the weevil.

The relative humidity during the day was much greater among the plants than at 3.5 ft. above the ground. During the night the humidity among the plants was very high and often reached 100 per cent. This shows a wide variation from the conditions that would be indicated by the use of the United States Department of Agriculture Weather Bureau records taken 3.5ft. above the ground. Precipitation records give very inaccurate information regarding the moisture conditions in alfalfa fields during the season that irrigation water is being supplied.

The adult weevils became active when the temperature reached from 10°C. to 12°C. Very few adults were found on the soil surface when the surface temperature increased to 35°C. or higher. No response of the adults to moisture, light and air currents was observed, and no evidence of flight by the alfalfa weevil has been observed in the field. The examination of stems in the field showed that 93 per cent. of the egg clusters were placed in green stems, 6 per cent. in dead standing stems, and 1 per cent. in dead fallen stems (rubbish). Thirty-six per cent. of the clusters contained from 6 eggs to 9 eggs, and 63 per cent. contained from 3 eggs to 12 eggs. Most of the eggs were deposited in the stems near the crown. Ninety-one per cent. were placed within 6 in. and 79 per cent. within 3 in. of the crown, and 85 per cent. were deposited in hollow stems. Hollow stems that are easy to penetrate seemed to be especially attractive places for oviposition. The larvae secluded themselves in the growing tips and axils of the plants when the alfalfa was disturbed by wind and rain. The larvae concentrate near the tops of the plants as long as food is available.

642. Using as his data observations taken at the Observatory of Perugia, situated at an elevation of 450 metres above sea level, from three stations in the plain at about 225 metres above sea-level, and two stations situated in the mountains, in Tezio and at Malbe, at about 625 metres and 635 metres above sea-level respectively the writer compared the meteorological conditions by day and night and in summer and winter at different altitudes.

On the basis of these observations and those taken at special stations on northern and southern slopes in the district, and also in selected localities, he shows how temperature and humidity vary according to aspect and exposure. A table of coefficients has been drawn up from which it is possible to correct the observations on temperature and relative humidity of the Meteorological Observatory at Perugia, so as to apply them to any part of the district. This enables the agricultural value of any locality to be assessed.

643. Experiments carried out with potatoes and barley over a period of 6 years have shown in a very clear way that yield does not depend only on soils and their need of manure, but also very largely on climate, and that with the changing character of climate in the course of a year, there corresponds different reactions of the different nutritive elements. Experiments with manures on the fields are not considered by the author as a proceeding exempt from estimation of the need of the soil for manure. In the same manner that each soil has a particular reaction with regard to climate or manure or the combined action of the two elements, so also each cultivated plant reacts in a specific manner to climate and soil.

644. In a previous publication the author showed that the evolution of carbon dioxide from mature apple fruits was affected when the tissue was frozen. Investigations were made subsequently to determine the catalase response of variously frozen apples.

It was found that extreme freezing of the McIntosh apple, in which most, if not all, of the cells were killed, markedly reduced the catalase activity, this effect coinciding with the corresponding response of carbon dioxide evolution. It is believed that the enzyme catalase is partly destroyed by freezing, along with the other cell contents.

The vascular tissue of the McIntosh apple gave an increased catalase activity when tested immediately after 3, 6, and 9 hours' freezing at an air temperature of - 7.5°C. The vascular tissue was found to have a greater catalase activity than the parenchuma. However, in both tissues catalase was greatly reduced after 20 hours' freezing.

The catalase measurements on the vascular tissue of Baldwin fruits were generally unsatisfactory. Immediately after freezing, the 6-hour and 24-hour treatments, and possibly the 9-hour exposure, showed a slight gain in catalase activity, while the 3-hour exposure gave results similar to those in the normal fruit. Three days after freezing, the 6-hour and 9-hour freezing induced a slight increase of catalase activity in Baldwin fruits, while apples frozen for 3 hr. and 24 hr. did not differ from the control. Seven days after freezing, the Baldwin fruits in the 3-hour and 6-hour treatments gained slightly in catalase activity, while

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in the tissue frozen for 9 hours it was somewhat retarded. In fruits frozen for 12 hr. and 24 hr. the results were similar to those in the control experiments.

645.* In Western New York, the survival of the grape berry moth during a normal winter was found to be rather closely related to amount of snow cover during periods when the temperature dropped to near 0°F. Snow drifting in vineyards on level or north sloping soil furnishes the most continuous cover for the cocoons and such areas constitute foci of infestation for the pest except during abnormal winters. Practical immunity is secured either by removing obstructions causing drifts or by avoidance of planting vines in such places.

646. The temperature changes occurring at the ½ in., 3 in., 6 in., 12 in., 24 in. and 36 in. soil depths as well as the air temperature are shown for the period 23rd Feb. - 25th Sept. 1925, and 20th Dec. 1926 - 20th June, 1927, by hourly intervals. The range in the air temperature during the 1925 period was 86°F. while at a depth of ½ in. the soil temperature range was 114°F. The range for the deeper soil areas was progressively smaller so that at 36 in. it was the least (31°F.). The range in air temperature during the 1926-1927 period was 81°F. while at a depth of ½ in. it was 76°F. The lowest air temperature recorded was 24°F. while the lowest soil temperature at the ½ in. depth was 32°F. The range for the deeper soil layers was progressively smaller so that at 36 in. it was only 24°F. The lag of the soil temperature as compared to the air temperature varied from less than 1 hr. at the ½ in. depth to approximately 80 hr. at 36 in. The various parts of plants growing in the field, such as the leaves, stems, and roots, are subjected to widely different temperature conditions. On 17th July, 1925, the leaves and branches were in air heated to 116°F., the stem (unshaded) just below the ground surface was in soil having a temperature of 143°F. while the roots were in a medium ranging from 107°F. at 3 in. to 84°F. at 24 in. The possible influence of soil temperature on the activity of bacteria, fungi, available N, chemical reactions taking place in soils, diffusion of dissolved material through roots and plant tissues, and rate of decomposition in soils is indicated by the seasonal temperature changes at various depths in soils.

647. Sir Gilbert Walker, while Director-General of Observatories in India, introduced the method of multiple correlation in connection with his work on the Indian monsoon rainfall, and has since extended the method to a study of world weather. In this memoir an attempt is made to apply the method to ascertain the effect of weather on the yield of Punjab wheat. The meteorological data used are (a) the Indus river levels as a measure of the irrigation factor. (b) the Punjab rainfall, and (c) the Lahore maximum temperature. Monthly values of these quantities are available for the years 1892-3 to 1926-7, and for the same period figures are given for the area sown with wheat, the gross outturn, i.e. the yield

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over this area, and for the outturn per unit area. It is found that the area sown, and in consequence the gross outturn, has increased over the period, particularly during the years 1900-12. The method the author has adopted of allowing for this trend is a little crude, consisting as it does in replacing the actual figures for area sown, gross outturn, and outturn per unit area by the deviations from overlapping five-year means. This reduces the number of years available for correlational work from 35 to 31, but unfortunately the author has not made the same adjustment to the meteorological data, with the result that the tests for the significance of the multiple correlations reached are no longer the ordinary ones. It would have been more satisfactory if the author had taken the deviations from some simple fitted curve, fitted to the same degree to both wheat and meteorological data, as in the method adopted by R.A.Fisher in his important study of the influence of rainfall on the yield of wheat at Rothamsted (Phil. Trans. Roy. Soc., B.213, 1924, pp. 89-142). As a matter of fact the author does not apply any tests of significance, for which tables are available, but contents himself with the statement of the actual values of the correlation coefficients, which range from .69 to .79. While it is probable that some, if not all, of these coefficients are significant, they are not very large, and any forecast of the probable area sown in the future, or the probable yield can only be made with an accuracy equivalent to a correlation coefficient of this order of magnitude. In a second set of calculations "fixed" normals are used instead of the adopted normals originally calculated, i.e. the departures in the case of area sown and gross outturn are calculated from broken straight lines, horizontal from 1893 to 1900 and again from 1912 to 1927, and sloping over the period 1900-12. As there has been no trend in outturn per unit area, the departures in this case are calculated from a horizontal straight line. It seems a pity that in this second calculation the author did not recalculate his cross correlations between the meteorological elements, but used the values obtained in the first study. This must again vitiate any tests of significance applied to the results. More use might have been made of the meteorological data in finding out what the influence of the distribution of rainfall, etc., throughout the harvest year has been in its effect on the yield of wheat. The importance of doing work to give some knowledge of the complex relations between weather and crop yield is now widely recognised - in this country, particularly, the Ministry of Agriculture, through its Agricultural Meteorological Committee, is carrying on an active investigation - and it is interesting to see that the same study is being pursued in India, and is yielding promising results.

648. Comparative determinations of the temperature fluctuations in the air at a height of 4.5 ft. and in the soil at depths of 0.5 in., 3 in., 6 in., 12 in., 24 in. and 36 in. were made in an area kept free from vegetation and not irrigated, with a view to the recording of maxima, minima, and averages for a day period, sunrise to sunset, and for a night period, sunset to sunrise. The terms of the experiment were 20th February to 30th September, 1925, and 1st January to 21st June, 1927.

The possible significance of such temperature fluctuations as were followed in the present series of measurements is briefly discussed, the methods and

equipment

equipment are described, and the results are reported both numerically and in the form of a number of curves illustrative of the general tendencies of day and night minima, maxima, and averages at various depths in the soil and for each of the two terms of the experiment.

At the 0.5-inch and 3-inch levels the day temperatures were higher than the night temperatures, but at the 6-inch and 12-inch depths the night temperatures averaged higher than those of the daylight periods in the 1925 series of measurements. At the depths of 24 in. and 36 in. there was no regular rise and fall of temperature during the 24-hour period.

649. The most important months for wheat development are April, May and June, i.e. the time from the tillering until the blossom stage. The enquiry into the variations (1) of the average temperature during the quarter of the year May to June, (2) of the customary total rainfall during this time, and (3) of the resulting yield, has already indicated the relation between yield and the meteorological factors.

In Central France it has been possible to observe that years favouring the growth of winter grain show in April to June a proportionately smaller rainfall and also a higher temperature than usual, whilst poor harvest years have a relatively greater rainfall. As a remedy, it is necessary (1) to drain the soil better; to provide root strengthening manures and to be careful to aerate the soil; (2) to destroy the weeds whose growth during abnormal rainfall is increased; (3) to build up varieties of wheat which give a high yield and are resistant to diseases due to excessive rainfall.

650. The writer has studied how, in France, the micro-organisms in the soil withstood the low temperature of February 1929, and has shown that the cold winter did not produce on them any sensible changes. On the other hand, several research workers have investigated the question whether the freezing of the soil had any effect in modifying the chemical properties. They conclude that the successive freezing and thawing did not produce any appreciable solubility of the potash or of the phosphoric acid in the soil.

651. For several years at the Station de Physique et Climatologie agricoles de Bel-Air, the writer has examined the influence the behaviour of the season has on the growth of the vine. During the horticultural year 1929 (in which there was an exceptionally cold winter and a fairly dry spring and summer), he particularly endeavoured to ascertain the functions of the principal climatic factors (that is to say, temperature, duration of insolation, humidity, precipitation, evaporation - which should be considered as the result of several other factors -) on the Aramon vine.

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To determine the influence of these different factors on its vegetation, he calculated from the 23rd April until the vintage at intervals of three to five days:-

(1) the mean temperature,
(2) the hours of insolation,
(3) the quantity of water fallen and the number of hours of rain,
(4) the mean humidity,

and at the same time he determined

(1) the growth of the vine branches (until the harvest had taken place),
(2) the increase in weight of the grapes from the time of flowering until harvest.

Evaporation was determined by means of a Piche apparatus which, if it does not indicate the quantity of water lost by the plant, gives some indication of the evaporating power of the air, that is to say, of the power that causes the plant to give up its water.

The growth curve of the vine branches and also the first part of the curve of the increase in weight of the berries, agreed with that of evaporation, whilst the second part of the curve of the increase in weight of the berries agreed with that for the humidity of the air.

Probably evaporation causes (particularly in a dry year) a greater rapidity of growth of the vine branches and a greater production of leaves; not by direct action - that is to say increasing the consumption of water - but by indirect action, that is to say, pushing towards the tips the nutritive liquid which favours cellular growth.

When vegetation is stopped and the berry swells (second part of the curve of the increase in weight of the berries), there is no longer any cell increase, but simply an increase in size. Pure water can produce this phenomena equally well if not better than saline solutions, and that happens because at that vegetative stage of the vine, atmospheric humidity has an indirect and primordial action.

In the first period of the vegetative growth, the principal part is played by the water which reaches the plant via the soil (water of precipitation, water of condensation, water of absorption), during the second, by the water present in the air (atmospheric humidity), but it is not certain that events always proceed thus. It so happens that if the meteorological progress of the year is exceptional the results may be different. If future observations allow any of the observations made in 1929 to be extended if not to all, at least to some dry years, there will be one more element for determining the time, amount and the form of watering necessary in an irrigated vineyard.

652. Parallel observations on temperature at 15 cm. above the surface of the soil and 10 cm. below it on a drained swamp and on a near-by mineral soil showed an average minimum air temperature about 4°C. lower over the swamp soil than over the mineral soil. The temperature

variations

variations were wider and the danger of frost greater in case of the swamp soil than in case of the mineral soil, thus indicating that the conditions for growing winter cereals are less favourable with the former than with the latter.

653. This is a review of studies on the relation of humidity to forest fires, with a list of 25 references to the literature of the subject. Practical applications of the humidity records in forest fire control are made.

654. This article describes the climatic characteristics of the different agricultural zones of Russia, and shows the close dependence of the agriculture of the country upon soil and climatic conditions, expecially the climatic extremes, which are quite pronounced.

655. The present status and outlook of agricultural meteorology are briefly summed up in 12 theses, which emphasise especially the importance of more intensive study of meteorological conditions immediately surrounding cultivated plants, including light as well as temperature and moisture; studies under controlled conditions which make possible the more exact evaluation of the effect of different factors; and co-ordination of the work of the meteorologist with that of the chemist, the physiological botanist, and others.

656. This bulletin is a revision of and supersedes Fmrs' Bull. 1096. Besides presenting general directions for heating of orchards, it gives rather extensive data on the cost of operation and on critical temperature under various conditions.